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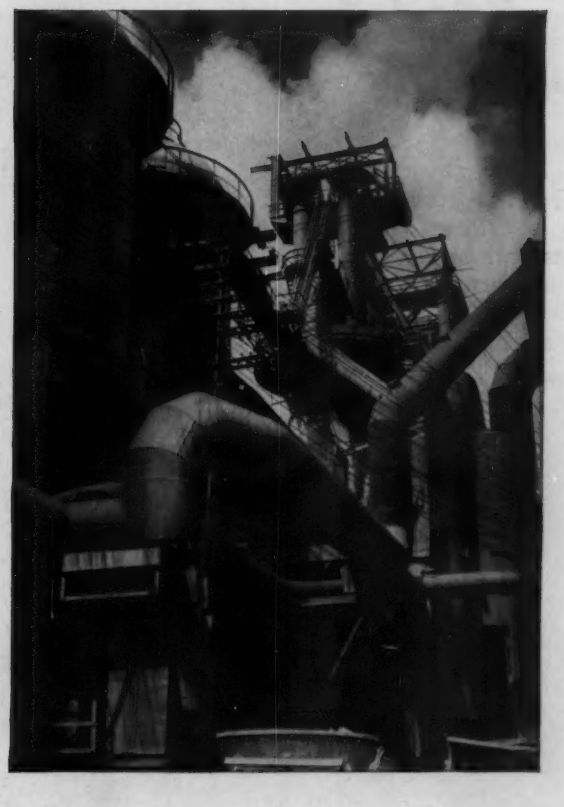
THE TECH ENGINEERING NEWS



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That Eyes May See Further

Commercialized Air

Flying Above the Weather

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Wearproof by Welding

Thus engineers obtain the service of the best alloys at the cost of ordinary steel

THROUGHOUT industry, wear on metals is an important cost factor. Until recently, most wearing parts had to be made entirely of special high-cost materials. Now, by welding, rapidly wearing surfaces can be covered with a wear-resistant alloy. Welded additions of bronze or Haynes Stellite—a wear-resisting alloy of cobalt, chromium and tungsten—create excellent wear resistance at low cost.

Long Life at Low Cost

Wherever metal has hard work to do, wearproofing by welding plays an important part. Under the toughest conditions, in mines and mills, in factories and on farms, in construction and oil-drilling, it is saving money and time.

Wearproofed parts will last many times as long as those made of unprotected iron or steel. Welding cost, including the necessary alloy, is only a fraction of the total cost of a new part. Then, after long, hard service, the part can be re-covered—another wear-resisting surface can be welded on at small cost, and the part is again as good as new.

Extensive Savings

Savings through the application of wear-resistant alloys are not confined to the lower cost of the part involved. Less power is used. Inventories are cut due to the consequently lowered investment and simplified control. Machine shutdowns for replacement are fewer. Maintenance costs are decreased, and a smaller crew can handle the necessary repairs. Further, the plant, without added equipment, can turn out a greater volume of production.

Figures drawn from case-histories where wearproofing is used are often surprising. A glance at the adjoining column will indicate many of the possibilities inherent in this process.

INTO THIS YAWNING CAVITY goes the dirt to make Grand Coulee Dam. Bucket front and teeth were hard-faced by welding. The result of this wearproofing was six months' service on Bonneville Dam, and many more months of trouble-free, repairless service on Grand Coulee.

Welding makes automotive exhaust valve seats good for 150,000 miles and more, with no regrinding in truck and bus motors, the toughest kind of service. These valve seats are wearproofed by welding Haynes Stellite to the contact surface. Ordinary cast-iron seats need regrinding every ten thousand miles.

* * *

Welding saved $2200 in one year for an Ohio pulp mill. Haynes Stellite was welded to the wearing surfaces of shredder knives. This work cost $90; knives, from the scrap heap, cost nothing. Hard-faced knives lasted for six months, and were again refaced by welding. New knives cost $200, last one month.

* * *

Welding a wear-resistant facing on the cutting edges of boiler-tube cleaners yields a twenty-fold saving—each cleaner will clean twenty times as many tubes as an ordinary cutter. When worn, hard-faced cutters are rebuilt for another long service.

* * *

Welding cured pump troubles in a pulp mill. Shafting on a sludge pump was wearing rapidly. Packing glands had to be tightened every hour, completely repacked once a week. The shaft was fast disappearing. Hard-faced by welding with wear-resistant metal, the shaft ran for three months with no attention, no appreciable wear.

* * *

Welding lengthens the life of blooming-mill shear clutches three times. Clutches previously ran 49 days, then went to the scrap pile. Now, wearproofed by welding, these clutches average 217 days before any attention is necessary. The same clutches are then refaced and used again.

* * *

Welding has solved an impossible lubricating problem. At a Southern mill where heater furnaces are fed by internal conveyor, rolls and bearings operate at 750 degrees Fahrenheit. Lubrication is impossible. A wear-resistant coating, built up on the rolls and bearings by welding, makes the conveyor last indefinitely, eliminates *need* for lubrication.

* * *

Tomorrow's engineers will be expected to know how to take advantage of this modern metalworking process. Many valuable and interesting technical booklets describing the application of the oxy-acetylene process are available without obligation. For further information write any Linde office.

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OUR AUTHORS

DR. HARLAN T. STETSON, author of the article *Evolution of Astronomy*, has recently been appointed a research associate on cosmic terrestrial relationships at the Institute. He is a graduate of Brown University, Dartmouth College, and the University of Chicago. From 1911 to 1913 he conducted a series of experiments which resulted in the development of the first thermoelectric photometer for determining the stellar magnitudes from photographic plates. His graduate work leading to the degree of doctor of philosophy was carried on at the University of Chicago. An appointment as assistant professor of astronomy at Harvard came in 1920, a position which he held until he accepted the post of director of the Perkins Observatory and professor of astronomy at Ohio Wesleyan University. Dr. Stetson is a fellow of the American Academy of Arts and Sciences, the Royal Astronomical Society, the American Association for the Advancement of Science, and many other scientific societies. He is particularly interested in the earth's crust, an investigation which involves studies of small variations in latitude and longitude.

PROFESSOR HURD C. WILLETT, writer of *Flying Above the Weather*, received his B.S. degree from Princeton University in 1924. After working in the Forecast Division of the U. S. Weather Bureau until 1927, he studied meteorology for a year in Norway and other European countries on a scholarship from the Daniel Guggenheim Fund for the promotion of aeronautics. He obtained his Ph.D. degree at George Washington University in 1929. Since then, he has taught meteorology at Technology as instructor, assistant professor, and associate professor. In 1934 he received the Sylvanus Albert Reed award for practical application of the Polar Front Theory to American weather maps.

PROFESSOR AVERY A. ASHDOWN, author of *That Eyes May See Further*, received his A.B. degree from the University of Rochester in 1914. After acting as instructor and obtaining his A.M. degree at that university during the next two years, he came to Technology as chemistry assistant in 1921. Here he obtained his Ph.D. degree, and in 1924 left for a year's research in organic chemistry at the Eidgenoessische Technische Hoschule in Zurich, returning to the Institute in 1925 as research associate in organic chemistry. He was subsequently appointed Instructor and Assistant Professor of Organic Chemistry. Since 1933 he has acted as Master of the Graduate House.

MAURICE L. SELLERS, '31, who wrote the article *Welded Ships*, was graduated in the Naval Architecture and Marine Engineering Department. While at the Institute, he was a member of numerous organizations, including Mortar and Ball and the Naval Architecture Society. He is at present connected with the Newport News Shipbuilding and Drydock Corporation.

JACK H. SCHAUM, '40, who wrote *Commercialized Air*, was graduated from McKeesport High School in June, 1936. He is registered in the Business and Engineering Administration Course at Technology. Besides being on the *T.E.N.* staff, he is coxswain of one of the Freshman crews.

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THE TECH ENGINEERING NEWS

MARCH, 1937
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HARRY O. SAUNDERS
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Technique

TOWERS AND PIPES

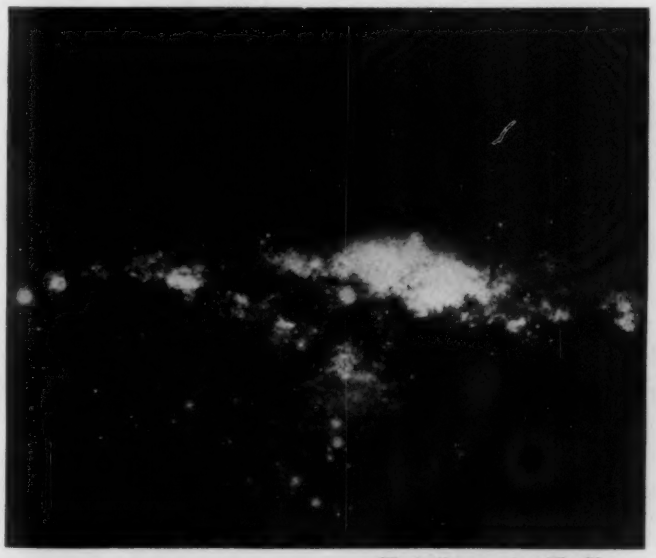
Evolution of Astronomy

Man Has Always Wondered About His Position In the Universe

Dr. Harlan T. Stetson

IF you've ever pitched camp in the Southwest desert lands and spent a night alone beneath the starlit sky, or if you've stood a lone watch during the long night hours on the deck of some little vessel hundreds of miles from land with nothing but the stars above and the seas beneath, I would venture to say you have caught a certain awareness of the universe around us not found by others who have never made such lonely ventures from the more conventional routine of human existence. One can, of course, see the stars from almost any locality. The distraction of Neon signs, highway flood-lights, and social companions, no matter how delightful, rob one, however, of that vital sense which comes when one is alone with the stars.

I remember as a youngster, first fascinated with the lure of the sky, stealing away from home just before sundown to spend the night on a neighboring hill-top in order to watch the panorama of the skies from sundown to sunrise to get a glimpse of the drama of creation as enacted before primitive man, who knew nothing of the wonders of modern science, and had to make of the universe around him what his untutored intelligence would allow. Fortunately with the ingenuity of science and invention, it has become possible for city dwellers to catch a realistic picture of the night-time sky in miniature in any of the planetaria of which several American cities can boast one. Those of you who may have visited the Hayden Planetarium in New York City, the Fells Planetarium in Philadelphia, the Adler Planetarium in Chicago, or the Griffith Planetarium in Los Angeles have probably not failed to note the element of awe and surprise unconsciously expressed by the audience when the lights in the lecture hall are extinguished and the overarching dome suddenly bursts into view with a very realistic starlit sky.



—Illustrations courtesy The Sky.

Milky Way with star cloud in Sagittarius.

Years have brought about vast changes in the world about us. Buildings of yesterday have been replaced by modern skyscrapers. City apartments have crowded dwellings to the suburbs. Concrete highways replace country roads and wooded lanes. The habits of men have changed. Society and politics are moving at a rapid pace. Yet, did you ever stop to think that the sky overhead is the same, that its planets and the sun and the moon are the same as they were centuries ago when the early watchers of the sky, somewhere in the Mesopotamian valley, began to study the positions and the movements of the stars in order that they might bring order out of chaos in the universe in which we live? Of course the universe is changing. Stars rush hither and yon at incredible speeds but the distances of these celestial objects are so remote that so far as any visible change is concerned, a thousand years are as yesterday when they have passed. What the universe really is, how it came about, and why there should be any universe at all are problems for a philosopher, and he will never answer them. Such questions, however, are so intriguing and so persistent that Man has never been content not to know more about the universe around him. His own life and mode of existence has undergone some of its vast changes as the result of his changing ideas of the universe in which he lives.

One is perhaps all too accustomed to think of the sky as something far removed from the earth. I remember a freshman who once wished to enroll in a course in astronomy because he was advised while he was in college to take some subject which never would have anything to do with anything that might concern his subsequent career, and he thought astronomy might fill this requirement admirably. On the other hand, modern astronomy tells us that we inhabit the surface of a tiny planet revolving about a second or third rate sun which is but one of many billions comprising our so-called galactic system. If, through some magic trick, we were to make the earth disappear, we should find ourselves veritably in the midst of the stars. We should need to change our position only slightly, as astronomical distances go, and we should find ourselves so far removed from the sun that it in turn would appear but a scintillating point of light lost among the myriads of stars all around it. The distance from the sun to its closest neighbors is not very different from the distance separating any two stars at random that we might pick out of the bewildering throng. Under such strange circumstances we should be bewildered as to any sense of direction. With the earth gone, there is no north, south, east, or west, for these are directions that depend entirely upon the invisible axis around which the earth is spinning. Neither would there be any up or down, for up and down are but directions referred to gravity, a force drawing all things to the center of the planet on which we travel. Even so, while in reality stationed on this planet Earth, we are in a very real way aboard an interspatial ship. Our problem of surveying the universe around us is somewhat complicated by the motions of this ship on which we find ourselves. Rotating on its axis once every day, we in the middle latitudes are being carried by this movement towards a certain region of the sky at a speed of some 600 miles an hour. Meanwhile, the earth is revolving about the sun. As we partake of the earth's orbital motion we are being carried at a speed of 18½ miles a second towards one direction in the sky this spring, and we will be going in the opposite direction next fall. The sun, a typical star which is dictator in the affairs of the solar system, is journeying toward the bright star Vega at a velocity of some 12 miles a second or 400 million miles every year. To para-

Regions of the Milky Way and the great Nebula of the Ophiuchus. Antares is the large star in the lower left hand corner.

phrase the words of another, "We are on our way," even if we do not know where we are going. Recent studies of the motions of the stars indicate that the whole galaxy of suns is rotating about a common center at such a speed as would carry us through one revolution in about two hundred million years. Investigations of the age of the earth tell us that the planet on which we live is probably some two billion years old so perhaps it is a bit consoling to know that the earth has survived at least several rounds of the galactic system during its ephemeral career.

Far beyond this galaxy of ours are the spiral nebulae, other galaxies of stars at distances so remote that observations of them in our telescope tonight tells us not where they are, but where they were, a million, ten million, or a hundred million years ago. Meanwhile, the axis about which the earth is spinning does not preserve a constant direction in space. It gyrates like the axis of a spinning top as it is pulled this way and that way by the gravitational forces of the sun and moon. Recent investigations clearly indicate that even the crust of the earth is less stable than we thought, so that perhaps our observations of the stars are made as though from a floating ice cake, lifting and falling a minute amount as tides in the solid earth surge beneath our feet. All these motions are reflected in the motions of the stars, and had to be disentangled before man could understand very much about the true movements of the stars themselves. No such complicated picture of creation presented itself to primitive man. He took the universe that he saw with his eyes very much at its face value. To him the stars were but luminous points apparently fixed on the inside of a hollow sphere which turned smoothly about the earth. Then, too, within this revolving dome the sun and moon and seven wandering stars — the planets — were seen to trace their movements against the background of the sky.

It is perhaps not surprising that man's first interest in studying the stars was a personal one. Knowing nothing of the true nature or the remote distances of these celestial objects, he saw them as embodied spirits influencing his affairs from day to day and year to year. Fortunate and unfortunate events were clocked by the aspects of the heavens. To protect the future course of his fortune, therefore, he must learn to decipher the movements of these celestial objects that he might foretell the recurrence of certain aspects of the sky, which coincided with significant events in the bitter experiences of mankind. The early astronomers were astrologers. Not until the Renaissance and the invention of the telescope began to show the true nature of the heavens did the superstitions of favorable and unfavorable aspects among the planets give way to an enlightened study of the heavens that should discover truth for truth's sake, irrespective of any personalized application.

The universe of yesterday was a geocentric one. Since no matter in which direction man looked, distances in the sky all appeared the same, the earth was naturally thought to be the center of creation. Since one experiences no sense of movement as the earth rotates and revolves about the sun, it was indeed natural that the earth should be regarded as a fixed body in a geocentric system. Only through the complication of cycles and epicycles in explaining planetary motion were the early astronomers led to the belief that the earth itself was a roving planet revolving about the sun once a year, and making the sky appear to turn once daily about the earth due to the rotation of the earth on its axis.

The champion of this new astronomy was Copernicus, who in 1543 published his revolutionary epoch-making book, *De Revolutionibus Orbium Celestium*, in which he set up a system of astronomy with the sun at the center of the universe, the earth taking its place among the other known planets, Mercury, Venus, Mars, Jupiter, and Saturn, which revolved about the sun. The book brought a storm of protest. For 1500 years men had come to believe in the simple picture of creation consistent with a medieval theology. So closely entwined were theological conceptions with a naive picture of creation that to alter the science of that day meant also the wreckage of theological doctrine. Copernicus died as the storm clouds gathered. Storms of controversy ensued, the reverberations of which lasted for nearly three centuries.

The transition from the geocentric system of medieval cosmology to the Copernican doctrine of a centralized solar system with the stars in the background presented the beginnings of a new era — a new conception of the universe. This was an era in astronomy concerned chiefly with the problems of untangling the puzzling riddles presented by our own planetary system. In providing the necessary data on which a true picture of the new order must rest, Tycho Brahe, a Danish astronomer, stands out as an immortal pioneer. With the true spirit of scientific adventure, he began to improve instruments and to make painstaking and systematic observations of the stars and planets in order that he or his successors might put to the test the relative merits of the geocentric and heliocentric astronomy in establishing the theory of planetary motions. Tycho's own opinions in regard to the outcome are of little concern. He proposed a compromise theory that still held the earth in the center of the universe, thus favoring the theology of those whose conceit demanded man at the focus of attention, the purpose for which creation had come to be. Then he let the sun revolve about the earth, and be the center about which all the planets except the earth revolved. His theory gathered little following but the observations which he made were the foundation material upon which Johann Kepler, an assistant of Tycho Brahe's, was able to announce three important laws of planetary motion: (1) that all the planets including the earth revolved about the sun in ellipses with the sun at one of the foci; (2) that the variable motion of the planets in these elliptical orbits followed a definite law stating that a line joining a planet with the sun swept over equal areas in equal times, as the planets pursued their circumsolar journeys; (3) that there was a certain harmony in the interrelationships of the distances and the periods of revolution of the several planets which could be mathematically described by saying that the squares of the times of revolution were proportional to the cubes of the distances of the planets from the sun. As Kepler stated them, these were

but empirical laws. They mark, however, an important milestone in the journey to the complete solution of planetary theory. For it was upon these laws that Newton was to develop his theory of universal gravitation and to sense that planets were held to the sun by an invisible force which varied inversely as the square of the distance. Newton was able to demonstrate his hypothesis by clocking the motions of the moon and showing that the moon revolving about the earth as a center performed exactly in accordance with this law. When applied to the motions of the planets about the sun, he showed that his conception of a gravitational law could be used as a basis for proving each of Kepler's three laws. With the publication of his complete theory of gravitation and the celebrated *Principia*, the mysteries of planetary motion were brought to a successful solution in the early part of the 18th century. The extension of the gravitational concept to a law of universal application as was embodied in Newton's statement that "every body in the universe attracted every other body with a force proportional to the product of the masses and varying inversely with the square of the distance between their centers" was a great adventure of the imagination. This adventure was completely justified when Sir William Herschel in the latter part of the 18th century demonstrated that existence of gravitational systems among the stars themselves. In search for periodical motions among the brighter stars with respect to close companions, Herschel found that in the case of many of the so-called double stars, the fainter of the two objects was revolving about the primary star in such a manner as to indicate motion in an ellipse. This was a factual demonstration of the law of gravitation amongst stellar systems.

As Copernicus stood on the threshold between the old order and the new, while opinions slowly moulded themselves from the geocentric picture of the universe to the heliocentric picture of the newer astronomy, so Sir William Herschel stands as a transition between the pre-telescopic era in astronomy, concerned chiefly with planetary motions, and the telescopic era which has gone far beyond the solar system into the outer regions of stellar astronomy.

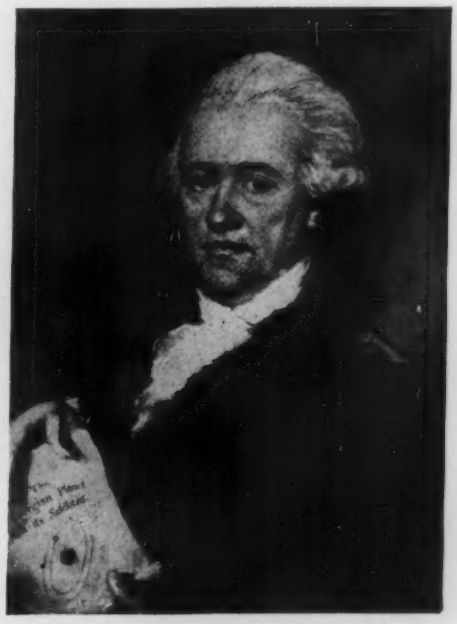
The telescope, whose origin as an optical instrument is still in debate, was first applied to astronomy by Galileo, who in 1610 startled the medieval philosophers with his discovery of four moons revolving about the planet Jupiter, a ring about the planet Saturn, spots on the supposedly immaculate sun, and the demonstration that the planet Venus exhibited all the phases of the moon, thus showing that it shone by reflected light from the sun. Galileo's little telescope revealed unnumbered stars invisible to the naked eye, showing that creation was far more extensive than the simple picture presented to the eye of man without optical aid.

The advances in the construction of telescopes due to the ingenuity and painstaking workmanship of Sir William Herschel is no less than astounding. It was Herschel who developed and perfected the reflecting type of telescope that is the model for our largest instruments today. By 1789 he had succeeded in completing an instrument four feet in diameter which was not exceeded until 1845 by a six-foot instrument constructed by Lord Ross at Parsonstown, Ireland. Such an instrument was not again equalled until the seventy-two-inch telescope was installed in the Dominion Astrophysical Observatory at Victoria, British Columbia in 1916.

It was particularly significant that in linking the era of planetary astronomy with that of stellar astronomy, Herschel should have made notable contributions in both fields. In 1781, he discovered the planet Uranus, a large planet revolving far outside the orbit of the planet Saturn, the outermost known of the classical planetary systems. The discovery of Uranus not only extended the boundaries of the solar system as the result of telescopic observations, but it later proved to be an important link by means of which in 1846 the planet Neptune was discovered. The discovery of Neptune was in itself a triumph for gravitational astronomy. Soon after Herschel had discovered the planet Uranus, it was found that its motions failed to conform strictly to that predicted on Newton's gravitational hypothesis. Before the middle of the 19th century, the accumulation of discrepancies in its motion made possible two assumptions: (1) that Newton's gravitational theory did not work at distances out beyond Saturn, or (2) that the peculiar and erratic motions of Uranus were due to the attraction of an unknown planet lying beyond, the existence of which, because of this very law of gravitation, was disturbing the movements of Uranus itself. On this second hypothesis, two brilliant mathematicians, Adams, an Englishman, and Leverrier in France, calculated the probable position of such an hypothetical planet. So close in agreement were the results of these independent mathematicians that it enabled the German astronomer Galle to turn his telescope to the region of the sky suggested by the calculations and within half an hour and within a moon breadth of the predicted place find the planet Neptune, thus making memorable in astronomical annals the night of September 12, 1846.

Leaving such planetary problems as might still exist to others, the pioneer spirit of Herschel pushed forward into stellar realms. Night after night, year after year, with telescopes of increasing power made with his own hands, Herschel penetrated the Milky Way, painstakingly counting the stars that swept through the view of his telescope, until by taking samplings here and there he built for himself a picture of what the universe of stars might really be like. His star counts revealed that the bulk of stellar systems lay in the general plane of the Milky Way. At right angles to this plane stars were relatively sparse. He pictured to himself, therefore, that the universe of stars must be shaped something like a crudely hewn grindstone with the sun and earth not far from the central plane. When we look out in the direction of the axis of the grindstone, we therefore see relatively few stars. Increases in telescopic power added little to the stellar population in these directions. Looking towards the periphery of the grindstone from our central position, we were looking through the long dimension of the universe. Thus stars crowded in

(*Continued on page 52*)



—Photo Courtesy Prof. Harlow Shapley

Sir William Herschel.
From a pastel by I. Russell, R.A. 1794.

That Eyes May See Further

Sensitizing Dyes Have Extended the Range of Photography

PROFESSOR AVERY A. ASHDOWN

PHOTOGRAPHY, the art of obtaining images of objects by the action of light on suitably sensitive surfaces, is held, generally, to rest its foundations on the sciences of optics and of chemistry. For centuries countless tiny openings through the canopy of the woods, permitting light to penetrate dense foliage, carpeted the forest path with bright circular discs of the sun's image and presented to mankind the principle of the pin-hole camera. For an equally long period the darkening of the skin in summer demonstrated the phenomenon of chemical change produced by light energy.

Such observations must remain dateless, and not until the early sixteenth century was there made an enduring record of the camera obscura. At that time, Leonardo da Vinci wrote an account, which has survived, and accompanied it with a diagram showing the path of the rays of light and the position of the screen and aperture. This account was not made accessible, generally, by publication until 1797 — the year in which Washington completed his second term as President of the United States. Lenses, introduced into the camera obscura in the latter half of the sixteenth century, were used generally only at a later date.

Clear recognition of the chemical aspects of photography came about a century after da Vinci's death in 1519. The German physician, John H. Schultze, more or less accidentally discovered the darkening effect of sunlight on the surface of a solution of chalk he had made by dissolving a sample of this material in nitric acid contaminated with silver. He demonstrated that the effect was due to the presence of the silver as an impurity and then proceeded to exhibit his discovery to curious people by showing how a design cut from opague paper could be reproduced distinctly on a sediment of chalk admixed with a small amount of a silver salt.

Remarkable as these effects were held to be in their setting of more than two hundred years ago, and depending as they did on the action of light on silver salts, they can hardly be interpreted as being the true forerunner of modern photography. A similar statement must be made concerning the Daguerreotype process in which a faint image on an iodine-fumed polished silver plate was developed by mercury vapor.

Distinction for pioneering in photography falls to workers in the early nineteenth century, especially to Thomas Wedgwood, a son of the renowned potter, Josiah Wedgwood, and to Sir Humphrey Davy. Their work is described in a paper published in 1802 under the title, "An Account of a Method of Copying Paintings upon Glass and of Making Profiles by the Agency of Light on Nitrate of Silver." Although the technique of these beginnings has long since been superseded by the familiar present-day gelatine emulsions containing silver halides instead of the nitrate, and by the use of developing and fixing agents, sensitizers, and so on, their honored place in the development of modern photography remains secure.

To this same early period (1777) belongs the far-reaching observation by the Swedish chemist, Carl Wilhelm Scheele, that the rate of darkening of silver nitrate was much greater for blue and violet light than for the red end of the spectrum. Eventually, it was shown that the ordinary photographic and the visual spectra were by no means coincident. The eye can detect so deep a red as that having a wave length of 7000 Å

—Photographs courtesy Eastman Kodak Co.

A view from White Face Mountain, N. Y., taken with Panatomic Film.

The view from White Face Mountain, N. Y., taken with Eastman Infra-red Sensitive Film 1-R.

while the photographic "eye" is not sensitive beyond 5000 Å. Indeed, silver bromide is sensitive only to the ultra-violet, violet and blue. Finding ways to make silver halides responsive to a wider range of spectra constitutes one of the major advances in photography during the past thirty years.

There have been at least two general approaches to this problem. The earlier one finds its most famous example in the preparation of very sensitive emulsions. Nearly sixty years ago, in 1880, Captain William de W. Abney of the Royal Engineers succeeded in making a silver bromide emulsion in collodion with which he photographed the infra-red end of the solar spectrum out to a wavelength of 9867 Å. He described his emulsion as blue to transmitted light and as being sensitive far into the infra-red region. It may have been capable of detecting lines of the spectrum up to a limit of 10,000 Å. This brilliant accomplishment apparently requires such a high degree of technique that only a few individuals have been able to reproduce it, and the method thus lacks wide practical applicability.

Meanwhile in 1891, George Higgs, in England, worked out a method for sensitizing photographic emulsions to the infra-red by treating them with the bisulphite compound of the dye, alizarin blue. "When obtained in a state of sufficient purity," he wrote, "the alizarin blue S leaves little or nothing to be desired, for, whilst possessing, in a high degree, sensitizing properties for rays throughout the region comprised between 6200 Å and 8000 Å, it does not lower sensitiveness to the violet and ultra-violet." This discovery proved to be the starting-point for the development of the now considerable group of sensitizing dyes. Their use has doubled the range of the photographic spectrum, made it possible to take pictures in total darkness, given the photographic "eye" the ability to look through haze and obtain superior aerial maps of great stretches of country as well as to gaze more surely into the depths of the stars.

A period of fifteen years of testing the effects of many different dyes culminated in 1906 with the proof of the pronounced sensitizing powers of the quinoline-base dye, dicyanine. P. W. Merrill and W. F. Meggers, using this dye at the Bureau of Standards in Washington, D. C., were able to photograph spectra out to 9,600 Å. Although this achievement was not as great as that of Abney, it had the distinct advantage of easy duplication.

Researches in the field of the cyanines (the quinoline-base dyes) showed that many members of this family of organic chemical compounds were remarkable sensitizing agents. Soon dicyanine was replaced by pinacyanol, which had a more general application.

Chemically these dyes are characterized by the possession of two nitrogen-bearing heterocyclic nuclei separated by a chain of carbon atoms containing what is known as a conjugated system of double and single bonds. It turned out that the longer this conjugated system separating the two heterocyclic nitrogen atoms, the greater was the sensitizing effect. Dicyanine, with its separating system of seven carbon atoms and pinacyanol with five were superseded in 1919 by the discovery of kryptocyanine having a conjugated system of nine carbon atoms. In 1925 neocyanine, with a separating chain of ten carbon atoms brought the sensitizing effect to so high a state of perfection that by super-sensitizing with ammonia a line in the solar spectrum located at 11,634 Å was photographed by H. D. Babcock.

The year 1932 saw a new group of these sensitizing dyes, known as the xenocyanines, discovered simultaneously in Germany and in England. In this type of cyanine, there are thirteen carbon atoms in the conjugated system separating the heterocyclic nitrogen atoms. It makes relatively easy photographing lines at 10,830 Å and, by suitable supersensitizing, at greater wave lengths. On account of their instability even at moderate temperatures, the more valuable cyanine dyes are rather difficult to handle. They may be applied either by bathing the finished plate with them or by incorporating them in emulsions. This latter method is the more preferred in practice. In the years since 1932, researches on these dyes and on many other types have been carried on steadily in the

(*Continued on page 49*)

Commercialized Air

Air Conditioning Is Now Considered Essential

JACK H. SCHAUM, '40

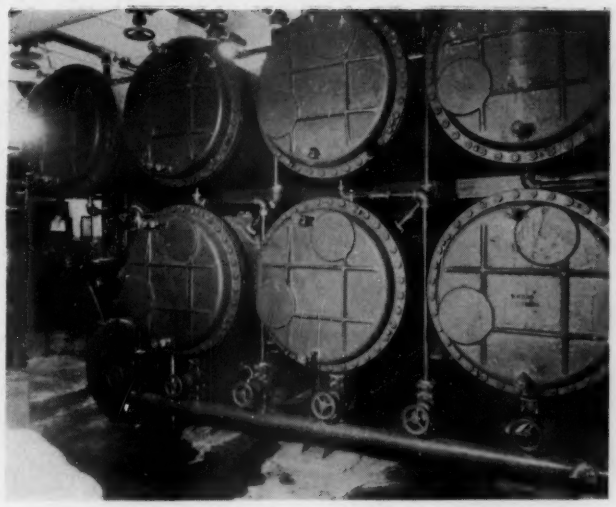
AIR conditioning has mushroomed into prominence in the past decade through its many applications to industry. You are all familiar with the comforts afforded by air conditioning installations in department stores and theatres. This commercial enterprise, air conditioning, has been nourished by practically every major field of production. In this article we will look into a few of the many examples of industrial dependence on commercialized air with which the layman does not come into direct contact.

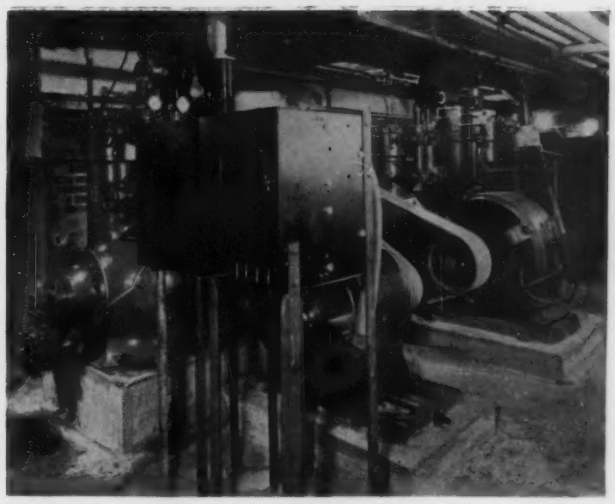
The conditions which exist in many South African gold mines today would make it necessary to abandon untold wealth if it were not for recent applications of air conditioning. At a depth of 8000 feet the temperature in the mines is 100 degrees Fahrenheit and the humidity is 100 percent. In these tunnels that are over one and a quarter miles below the surface, conditions are almost unbearable and have a drastic result on the efficiency of the miners. American heat engineers are solving the problem and the Union of South Africa has cancelled tariffs on refrigerants to assist South African miners and in turn American air conditioners. Mechanical cooling has succeeded so well in the Robinson Deep gold mine, deepest mine in the world, that another mine, the East Rand Propriety Mine, has contracted for similar equipment. The air conditioning machinery of the Rand mine will be installed in a room hewed from solid rock 6500 feet below the ground. Comfortable working conditions will be had by supplying 150,000 cubic feet per minute of cooled and dehumidified air to the lower levels of the mine. According to a statement issued by the Bureau of Foreign and Domestic Commerce of the United States Department of Agriculture, the extension of air conditioning throughout the thirty-eight gold mines now in operation is a foregone conclusion and will involve an enormous expenditure for machinery and equipment.

Mines all over the world are confronted by the serious problem of air pollution. Some of the factors contributing to mine air pollution are: (1) Carbon dioxide resulting from decaying timber, exhalation from workers, naked lights, and blasting; (2) Hydrogen sulfide, sulphur dioxide, nitrogen oxides, and carbon monoxide as gaseous products of explosives, high sulfide ore bodies, and rotting timber; (3) Gasolene engines and locomotives; (4) Dust from drilling and blasting. Increased volumes of air, made possible by scientific ventilation, can dilute all but the last of these pollutions. With the installation of air washing apparatus it is possible to clean air containing as much as 150 to 300 milligrams of impurity per cubic meter. The presence of foul odors in mine air has a serious effect on labor efficiency. This problem has recently been dealt with by using ozone, which is an excellent de-oderant, because it readily oxidizes foul smelling elements in the air. The carbon impurities in the air combine with the third

—All illustrations courtesy Heating, Piping and Air Conditioning.

In the plant and warehouses of Bayuk Cigars, Inc., over sixty are conditioning systems are in year round operation.





Two 70 ton and one 100 ton ammonia compressors for air-conditioning in the Hotel Statler, Boston.

oxygen atom in ozone to form carbonic acid gas, which is odorless, colourless, and tasteless. Since carbon and its compounds are the main sources of undesirable odors in the mines, it is but a matter of conditioning the air with a sufficient quantity of ozone to remove these efficiency-lowering pollutions. Thus, "man-made atmosphere" has conquered industry below the ground and has literally given the miner a refined atmosphere in which to work.

The stronghold of air conditioning, however, lies above the shafts and tunnels of mines. Let us first consider the printing industry, which has become subsidized by mechanical weather. Paper has the ability to adjust its moisture content rapidly with variations in the relative humidity of the surrounding air. All moisture content changes are accompanied by a corresponding contraction or expansion of the paper. When paper gives up its moisture in a dry atmosphere, a wavy edge results and makes it difficult to feed the paper through the press. A humidity variation of but five percent will cause a distortion of three hundredths of an inch on a sixty inch sheet, which is a sufficient deformation to cause serious misregister and poor quality. This shrinkage and stretching of the paper is greatly magnified in color printing since one color is printed, and from several hours to a day elapse before the next colors are added. If the weather conditions vary during this time, the paper will undergo dimensional changes and a poor quality of printing invariably results. With the constant humidity afforded by air conditioning, the printer need never to fear for the quality of his work.

Plates which are to be used in four color printing must be cleaned of all the old ink, film, and foreign matter to insure satisfactory results. Unless the humidity is below sixty-five percent, the removal of the undesirable substances is effected only with great difficulty. It was formerly necessary to wait for proper weather conditions to perform this operation and maintain good quality, but thanks to mechanically controlled humidity, this loss, delay, and general dissatisfaction have been replaced with superior workmanship and absence of shutdowns and delays. Press rollers, which are made of glue and glycerin, are very sensitive to atmospheric changes. On warm or damp days production is slowed down considerably and rollers are damaged. The Waverly Press Inc., of Baltimore, reduced its roller bill by an amount of $384 for the year as a result of installing air conditioning. The amount of ink spoiled by lint and other foreign substances in the air is greatly reduced by the air washing apparatus.

Another production problem in printing is electrical. When the relative humidity is too low, the air becomes a poor conductor of electricity. The static electricity generated by the sheets of paper going through the press will cause the sheets to stick together and to adhere to the press itself. An artificial atmosphere dissipates this drag on the presses and allows printers to take another imaginary step toward that elusive madness called "speed."

We shall now have to take a mental gelandesprung from the printing press to the railroad train. In the application of air conditioning to trains, one might say that science is indeed resourceful. Since it could not open the Pullman window, it invented air conditioning. Not much effort was ever made to open that window once air conditioning became practicable. The railroads immediately began to regain lost customers and pull themselves out of a disastrous slump in business. One railroad attributes to air conditioning an increase of twenty-eight percent in travel during the summer months. Ever since the first air conditioned car (a diner) was placed in use in 1930 there has been a rapid trend toward conditioning all the passenger cars on the major railways. By the end of 1935, railroads had spent $50,000,000 for air conditioning passenger cars and at the close of 1936 there were 8000 mechanically cooled Pullman cars. The cost of cooling units, covering depreciation, maintenance, and operation, is at present about equal to the revenue derived from one passenger in each car.

The busses apparently are not to be outdone by the railroads in offering this comfort to passengers. An air conditioning unit, with compressors run by the motor, has been developed for use in busses and automobiles. It is compact to the extent that all the elements will occupy a combined space of less than a three-foot cube. Passengers will not be bothered by other occupants' smoking and the 14,000 B.T.U. an hour

(*Continued on page 48*)

Air-conditioning in a bakery — apparatus in background.

Welded Ships

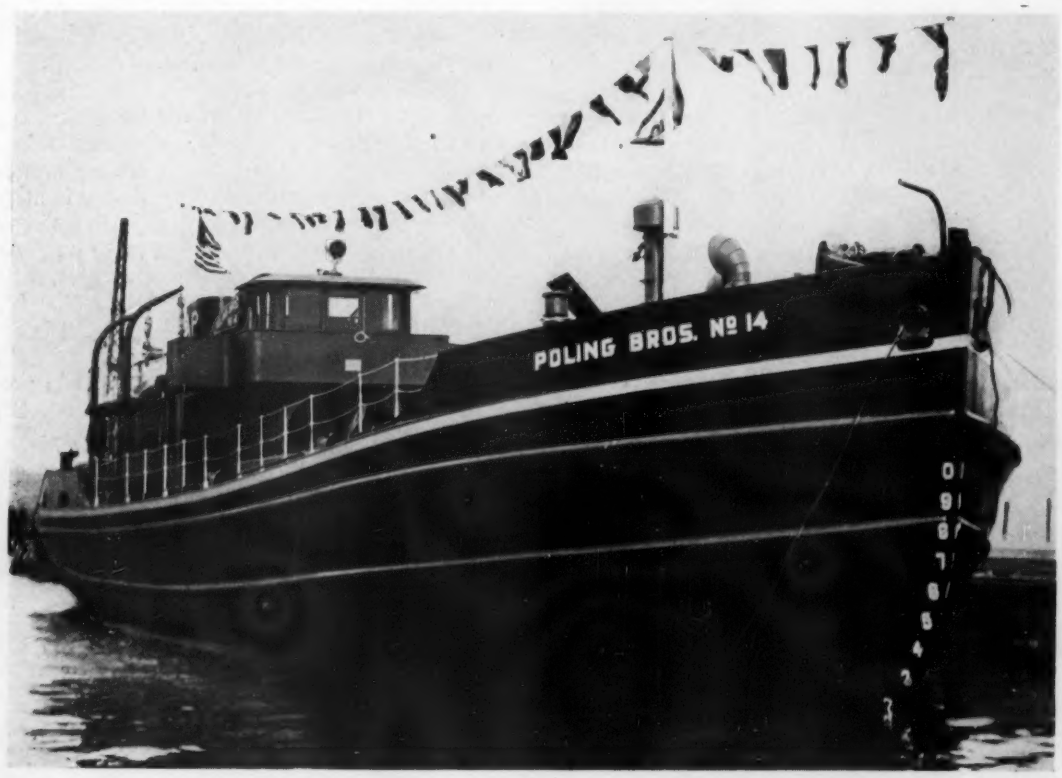
Today They Are Steadily Replacing Riveted Vessels

MAURICE A. SELLERS, '31

IN recent years, the art of shipbuilding has made definite and rapid progress along three fronts, namely: hull construction and design, propelling machinery and mechanical operation, and yard operation and production methods. In these days of highly developed mechanical and electrical devices mass production methods have been applied to all industries of importance. It has been only natural that the shipbuilders and ship owners have borrowed freely from modern industrial methods, and have developed and applied them to their own uses to produce that masterpiece of man's ingenuity known as a ship. The line of development dealing with the design and construction of hulls is peculiar to the shipbuilding industry alone. Our advancement in this direction has been the fruit of our investigations, together with those of the metallurgist, combined with the lessons taught by experience. We have watched the development of ships from wooden to steel structures. The latter we have seen grow from the use of hand-riveted joints to the less costly and more efficient pneumatically-riveted joints and now we are undergoing another evolution, the elimination of riveting and joining the various parts of the ship by welding. It is this latter subject that we wish to discuss at the present time and thus take this opportunity to analyze how far we have come and what the prospects are for the future.

Before the period 1917–18, metallic welding consisted chiefly of forge welding processes, similar to those employed manually by the blacksmith, by the use of mechanical hammers and rolling devices. It was by such processes, in conjunction with riveting and casting, that our steel hulls were fabricated. During the war emergency the application of fusion welding by the electric arc sprang into prominence in making repairs and in the construction of structurally unimportant details of a ship. In the ensuing years, the possibilities of such a process became more evident and its value to shipbuilding was recognized early by a few scientists, engineers, and some shipyard executives. Simultaneously, the Bureau of Construction and Repair of the Navy Department authorized an extensive welding research and development program. This program received added impetus by the limitations on displacements of naval vessels instituted by the Treaty Limiting Naval Armaments (1922). Since the limitations put a special premium on the weight of these ships, any process, such as welding, that tended toward weight reduction was tackled with enthusiasm. Since the maximum benefit is to be obtained by the attainment of the highest welding efficiency, the result has been the raising of welding standards to what they are today, and has brought about enough confidence in the method to have extended its use to a considerable portion of the structure of naval ships. This progressive attitude on the part of the Navy Department has resulted in this class of ships being the best examples of the application of electric welding that we have at the present time. The experience thus gained is, of course, going to be reflected in any type of ship that is constructed in the future.

From the very beginning, the management at Newport News has endeavored to keep in step with the development of



—Courtesy Marine Engineering and Shipping Review.

An electric arc welded motor tanker.

—Courtesy Proceedings of the Naval Institute.

Two new welded destroyers at the Boston Navy Yard.

welding in connection with ships, and, to this end, have sponsored considerable pioneer experimental work in its testing-material laboratories. A few years ago there was established a welding school for training men in this new trade. Eventually these men were welding such hull structures as masts, pillars, bilge keels, and foundations on merchant vessels, and later formed a nucleus of our present large welding crew that are successfully carrying out the Navy Department's current program of welded ships. Today the experimental work, together with the welding school, is a major activity at the plant, and corresponding systems have also been adopted in all of the major shipyards in the country. Today any new application of a welding process is first preceded by considerable research, a procedure that is safe and, up to the present time, has produced satisfactory results.

In order that our historical background be complete, it is well to mention the progressive attitude of the American Bureau of Shipping, which in 1927 issued rules for the classification of all welded ships. So far, this classification has consisted of small boats such as tugs and barges of comparatively simple structures up to about two hundred and fifty feet of length. The classification of such vessels is followed by the notation *Metal Arc Welded.*

The various types of welds now employed in construction work are so well-known by every engineer and designer that it does not seem necessary here to describe them. Of these various types, metal arc welding is now being used almost exclusively for making joints in ships' hulls because such a process has been found to have the greatest all-around efficiency. This method permits better control and reduces heat effect which creates excessive buckling of plates. Because of their superiority, covered electrodes are now being used exclusively on all important work. Previously there has been much discussion, pro and con, of bare, versus covered electrodes, but the latter produce welds whose properties are so near that of the basic mild steel that their use is well justified, although the initial cost of the rod is a bit more. With covered electrodes the metallic welding rod is coated with a compound that during the welding process serves as a flux preventing the formations of harmful nitrides and oxides, thus increasing the strength, ductility, and corrosion-resisting properties of the weld.

The fundamental advantage of welding as a substitute for riveting is, of course, the opportunities offered for reduction in weight of structures. This fact alone has probably been the greatest incentive to the development and application of welding to ships. Its importance hinges on the simple maxim that, for a given displacement, the lighter the hull structure, the greater the cargo capacity carried; and for naval vessels, a greater number of guns and heavier armor is possible. The obvious reason for this weight reduction is the elimination of connecting angles, butt straps, and laps. When these, for one reason or another, are deemed necessary, their size can be greatly reduced below that required for a riveted joint.

Another reason, perhaps not quite so apparent at first, is the possibility of distributing material more economically and putting it where it does the most good. Sections can be fabricated strictly for the purpose for which they are intended without resorting to the modification of other structural shapes rolled for another purpose entirely. Reinforcement can be added easily at the location where reinforcement is needed without the loss of efficiency created by rivet holes. One hundred percent joint efficiencies are possible, a factor hardly ever obtained with rivets. Simplicity, symmetry, and continuity of structure are obtainable and are factors of which the designer can take advantage to reduce his margins of safety by the elimination of various uncertainties caused by unsymmetrical and discontinuous sections. In a riveted structure under high stress there is always the possibility of rivets slipping and angles spreading, thus shifting their share of the load to some other part of the structure that is already highly stressed. The results of such a condition may sometimes prove disastrous. What is actually done in these cases is that stresses are kept low to guard against this possibility. This means the addition of more material, hence more weight. It is not a wonder, therefore, that our designers are doing their utmost to utilize a tool like welding that, theoretically, eliminates these grave uncertainties and thereby furthers the cause of weight reduction.

Another argument in favor of welding that can not be overlooked is improved tightness of joints. Leakage is reduced by removing the presence of rivet slippage along with the aboli-

tion of the rivet hole itself. In the past, much trouble has been caused by the excessive corrosion of rivets in steel plates. This problem has been more acute in the case of oil tankers. It is felt that welding exhibits better anti-corrosive properties, a fact that has been utilized recently in the construction of tankers where welding is used extensively in the tank spaces.

Economies in erection are utilized by making as large sub-assembly groups as practicable on the ground or in the shops. This procedure lends itself very nicely to welding by offering simple mechanical means of clamping, and permits welding under ideal conditions. In this manner work can be handled easily, the proper allowances for shrinkage made and adjusted for, and excessive warping straightened before the unit is put in place.

With these advantages in favor of welding, what are its limitations and to what extent has the shipbuilder found it practicable to apply them? The sea is a hard taskmaster. For this reason, from the very beginning every new attempt made by man to overcome the sea has had to be tempered by past experience; every lesson that has been learned must be utilized. Whenever departure has been taken from this principal the results have been disastrous. Shipbuilders have been accused of being too conservative. Whether this is true or not depends perhaps, upon the point of view, but it is true that any radically new idea must be given the deepest consideration before its adoption. Failure of *any* engineering enterprise is bad, but today, the lives and money at stake aboard a liner make the loss so tremendous that any possibility of risk is prohibited. On land, any units of locomotion can be readily tested for any service conditions. This is also true of aircraft which have the added advantage of being capable of avoiding extreme conditions in service. However, who can anticipate the loads induced upon a ship by a North Atlantic gale? Under these conditions a vessel is subjected to every dynamic and static type of loading imaginable and of unmeasurable magnitude. Thus we can test the various processes and units that go into a ship before erection, but the final test of the assembled structure is furnished by experience and time.

The all-welded ships of every size are yet to be built. Whether such will be realized in the near future is problematical. Even if the welding engineer removes all doubt of the realiability of his product, and he is fast doing so, there still remain many hurdles to take before we can forget our rivets entirely. Actually, welding technique has progressed more rapidly than design. By the use of rigorous tests and proper supervision it is now possible to secure welds of good workmanship and uniformity in character. By elimination of the requirement of brute strength it is possible to draw upon a much larger field for these workers. But there is yet the problem of erection which unfortunately tends to eat up any savings that can otherwise be gained by welding. The special means required to secure the necessarily neat fit of joints is very costly. Warping and shrinkage are always present and must be removed or at least reduced to a minimum. As stated above, ground work makes it possible to surmount some of these difficulties, but final erection in the hull proper is another story. In ships containing the maximum of welding thus far attempted, it has been very difficult to have the finished product near its intended shape and dimensions. Undoubtedly the gradual accumulation of data and experience will help this situation. At present before a vessel is started, the whole welding procedure is studied very carefully and every effort and allowance made to counteract shrinkage. It is only by such systematic and comprehensive study that we shall get anywhere.

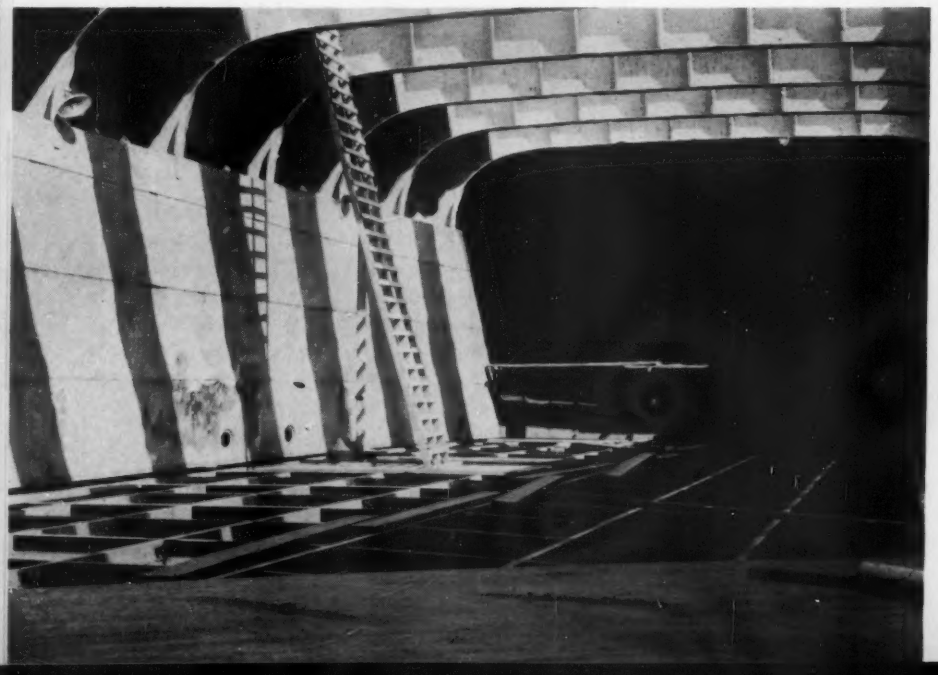
A further consideration is the lack of rolled sections designed for use with welding. It is possible to build shapes from plates and flat bars to meet practically any requirement, but for the reasons stated these are costly. Nearly all of the steel shapes now rolled are for riveting so that considerable flame cutting is necessary to prepare them for the welding process. Unfortunately, the shipbuilding industry does not consume enough steel to make it economical to have these sections made. Until the demand, by other industries, for weldable sections becomes greater, there is probably little that can be done about this handicap. There should be concerted action on the part of structural engineers to develop standard sections to remedy this situation.

For a long time naval architects have been utilizing high tensile and special treatment steels as a means for weight reduction of ships' hulls. Since arc welding confines us to low carbon steels, there arises the question as to whether anything is gained by replacing these special steels with that which is weldable. In the larger ships, the use of high tensile steel for longitudinal strength members, even though riveted, undoubtedly offers the most gains. Actually there is not much to be gained by using welding in any longitudinal strength member since, with everything else equal, the section modulus of the ship's girder is going to depend upon the area of metal alone in its cross section.

Because of these considerations, we now find the structures of our larger vessels sixty percent welded. To date, with the exception of a few tankers, such vessels have been warships. Merchant shipbuilding has been practically nil during the past few years. When the latter are built, however, it is probable that welding will be utilized to a considerable degree. Welding in the former includes parts of the shell plating and decks, transverse framing and bulkheads, longitudinal bulkheads, pillars, deckhouses, piping, foundations, and myriads of fittings. Several large castings, as stern posts and stems, are now replaced by weldments. To what extent such welding will be carried in merchant vessels will depend entirely upon how far ship owners are willing to go. Since the merchant ship must pay its own way, initial cost is a greater factor here. Under present conditions it seems possible that such main structural items as bulkheads, floors, decks, and deckhouses can be welded without any appreciable increase in cost or time for building. This would amount roughly to a saving of six percent in steel weight, or expressed differently, that much more cargo could be carried than could formerly be handled in the same vessel without the use of welding. It has been estimated that, for cargo ships, a maximum saving of sixteen percent of the structural weight is possible in an all-welded ship.

(*Continued on page 47*)

—*Courtesy Marine Engineering and Shipping Review.*



Welded tank top being installed on Great Lakes bulk freighter.

Flying Above the Weather

A Meteorologist Discusses the Possibilities of Using the Higher Airways

PROFESSOR HURD C. WILLET

FREQUENTLY, when the feasibility of commercial high altitude aviation is being discussed,one hears the statement made that one advantage of flying at such high altitudes is that one would be "above the weather." Usually the altitude of the flight which is under consideration is in the region from 20,000 to 30,000 feet above sea level. To say that at such altitude one is above the weather is in itself a rather meaningless statement. The term weather applies to the complete dynamic and thermodynamic state of the atmosphere; consequently, wherever there is atmosphere there is weather. What the speaker usually has in mind when he speaks of weather is weather unfavorable to the operation of aircraft. Even if it is assumed that at such altitudes one is above unfavorable weather conditions, the principal bad weather hazard, that of coming down to the landing, has to be met just the same, at whatever altitude the flight is made. However, there are many hazards, particularly that of icing, which might be largely eliminated if it is true that flight at 25,000 feet altitude brings one above unfavorable weather conditions. For this purpose we shall consider in turn conditions of wind, temperature, turbulence, and condensation forms from the point of view of icing. It is, however, well to preface any such discussion by emphasizing the fact that the amount of direct observations of these elements in the atmosphere at altitudes between 20,000 and 30,000 feet is quite scanty and at higher altitudes vanishingly small. For the area covered by the United States the direct observational data are restricted mostly to that area lying between the Atlantic coast and the eastern slopes of the Rocky Mountains. When the discussion is extended to cover territory lying outside of this region, it must be based more on hypothesis and on comparison with conditions which are known to exist in other parts of the world. To make the discussion as specific as possible it will be restricted for the most part to two definite levels, those of 20,000 feet and 30,000 feet above sea level, and except where otherwise specified, to a latitude of 40°. This corresponds roughly to a line from New York City to Kansas City, Cheyenne, and Salt Lake City.

During the winter season the mean wind velocity at the 20,000 foot level, near latitude 40°, decreases as one goes westward from about 65 m.p.h. at the Atlantic coast to about 48 m.p.h. in the central plains states section. The prevailing direction shifts from westnorthwest slightly towards the northwest in the same region. At the 30,000 foot level the corresponding mean velocities are found to be 85 m.p.h. and 62 m.p.h., and the shift in the prevailing direction to be from slightly west of westnorthwest to due northwest. Probably these wind velocities would continue to increase to the eastward, reaching a maximum from the west at some point over the mid-Atlantic. To the westward they would probably continue to decrease, reaching a minimum velocity with a maximum northerly component over the highest ranges of the Rockies. Further to the westward over the Pacific the winds probably would increase rapidly in velocity and blow principally from the west. During this season the mean velocity of these upper winds in the central United States is found to be very nearly the same at the Gulf coast as at the Canadian border, but the direction at the southern latitude is definitely more from the north than at the northern latitude. From these figures it is obvious that as far as transcontinental flying is concerned, unless westward flights can be made at a much lower altitude than eastward flights the speed would be considerably reduced by the winds at the higher levels. As far as trans-Atlantic flight is concerned, it would probably be found in winter at the 20,000 foot level that the westerly winds diminish rapidly from altitude 30° southward to latitude 20°, and that southward from this latitude their direction would be reversed with increasing velocities from the east. At altitudes higher than 30,000 feet, the prevailing westerly winds in the central United States would probably be found to increase during the winter season up to an elevation of 35,000 feet or slightly more, and above that level to decrease very rapidly through the next 10,000 feet.

The mean wind velocities during the summer season at the high altitudes run slightly less than half the value they have in the winter season. At latitude 40° and at the 20,000 foot level, the mean wind velocity decreases from about 30 m.p.h. on the Atlantic coast to about 18 m.p.h. in the central part of the country, while at the 30,000 foot level the corresponding velocities are 40 m.p.h. and 28 m.p.h. Probably a corresponding mean velocity would be found over adjacent regions. The prevailing directions over the eastern United States are found to be very nearly the same as in winter, but generally with a slightly larger component from the north. Whereas during the winter season there is a slight increase in velocity in the high altitude winds from the Canadian border southward to the Gulf coast, during the summer season there is a decrease of at least 50 percent, the wind velocities over the southern United States even well above the 30,000 foot level becoming light and irregular. During this season south of latitudes from 28° to 30° the winds are probably prevailingly from the east at all altitudes from the Gulf of Mexico eastward across the Atlantic. During this season also the elevation of maximum wind velocity over the central United States, above which the velocities decrease very rapidly, will be found to lie probably some 5000 feet higher than in winter, above the 40,000 foot level.

There is much less data on temperatures at high altitudes over the United States than on wind velocities. However, the mean temperatures in this area at latitude 40° up to the base of the stratosphere have been fairly well determined. In winter the average temperature is found to be about −25° F. at the 20,000 foot level and about −52° F. at the 30,000 foot level. During the summer the corresponding values are found to be about +9° F. and −18° F. respectively. Intermediate values would be found in spring and autumn. These values presumably increase somewhat to the southward and decrease to the northward. Temperature in itself is not a very important consideration as far as the feasibility of commercial aviation is concerned, except for the fact that the zones of most probable icing conditions are determined to a considerable extent by the temperature distribution.

The occurrence of turbulence, or in other words strong vertical convection in the atmosphere, depends on several factors. Of first importance is the temperature lapse rate in the atmosphere or the rate at which the temperature in the free air is found to decrease with elevation. The steeper the lapse rate, or more rapid the decrease with elevation, the greater will be the tendency for strong convection currents to occur.

(*Continued on page 46*)

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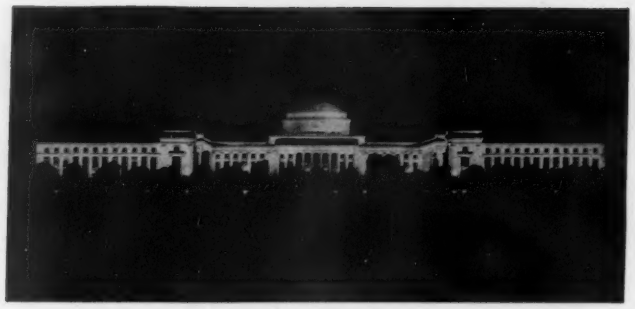
Illinois Technograph
Iowa Engineer
Iowa Transit
Kansas Engineer
Kansas State Engineer
Marquette Engineer
Michigan Technic
Minnesota Techno-Log
Nebraska Blue Print
New York University Quadrangle
North Dakota State Engineer
Ohio State Engineer
Oregon State Technical Record
Penn State Engineer
Pennsylvania Triangle
Purdue Engineer
Rose Technic
The Tech Engineering News
Villanova Engineer
Washington State Engineer
Wisconsin Engineer



EDITORIALS

PRACTICE IN PIONEERING

EVERY year a small percentage of students remain at the Institute after graduation in order to work for masters' or doctors' degrees in their chosen fields. The majority of students, having attained their bachelors' degrees, start hunting for jobs at once, and, judging from the figures available, very few fail to "place" somewhere. Perhaps for the very reason that so many Technology graduates have in the past been able to find employment after the regular four year curriculum, many students do not consider seriously the advisability of advanced study. There is an all too widespread ignorance and lack of appreciation of the value of staying on to work for higher degrees.

Consider the research work done in the Chemistry Department, one of the large departments of the Institute. Each year a certain number of men who receive their bachelors' degrees in Course V remain at the Institute to work for masters' and doctors' degrees. In accordance with the type of work they are interested in, they are assigned to one of the three research divisions, the organic, inorganic, or physico-chemical. The men usually carry on experimental work under the supervision of professors. In the organic branch in particular, the research work done by the students is often in the nature of problems of interest to certain industrial concerns which may eventually employ them. For example, research work is done on dyes, sugars, vitamins, cellulose, the products of turpentine, and the action of certain catalytic agents such as aluminum chloride.

In the inorganic division the work is primarily of theoretical importance, but although the results of this research are not quite so applicable at present to chemical industries, most of which depend upon organic reactions, work is being done by research students which may have a decided effect upon the future of chemical industry. The similar behavior of carbon and silicon, the chemistry of boron, the effect of sound on chemical change, and the quantitative determination of selenium, tungsten, and zirconium are topics of research. In the division of physico-chemical research, students are studying the molecular properties of matter at low temperatures and high pressures, as well as other topics more applicable to industry such as the equilibrium of chemical reactions as a function of pressure and temperature, and the deviations of gases and solutions from the ideal laws.

Even if the processes operated by outside companies are not in any way connected with the work which these students may be doing, they will be glad to employ them, simply on the ground that, having had an extra year or more of work of research nature, they will have acquired a general training which will prove beneficial to the company in the solution of its own specific problems. As a rule, companies are looking for the type of man who can tackle any problem which may confront him, rather than the specialist in any particular

phase of work. The chief advantage a man receives from pursuing his master's or doctor's degree is this practice in doing pioneering work. His value as a specialist is of secondary importance. In fact, to quote one professor in charge of research, the primary purpose of research is "to train men." The extra years which these men spend in getting that training prove well worthwhile, for it is a matter of fact that men with the higher degrees get better jobs and salaries in a shorter time than men starting out with bachelors' degrees.

INDUSTRIAL CONCILIATION

A TREMENDOUS step toward industrial co-operation and conciliation has been taken by the Carnegie-Illinois Corporation, the largest subsidiary of United States Steel. With the announcement of a forty hour week, increased wages, and commencement of negotiations with industrial unionists, this company has caused great relief to industry and labor alike. Previously it had appeared that the country might experience in the steel industry a more bitter struggle than the General Motors strike. But this likelihood has been averted by the agreement of the corporation to open negotiations with an industrial union, the Amalgamated Association of Iron, Steel, and Tin Workers.

This action of voluntarily increasing wages and shortening hours before the changes were demanded by force has improved considerably the position of the steel industry in the eyes of the public and labor. It is a worthwhile attempt to improve industrial co-operation and peace so necessary to a democracy. It definitely indicates a willingness on the part of industry to take a lead in the solution of our economic and social problems.

In return for such favorable treatment, the union, which is a member of the Committee for Industrial Organization, has shown a desire to co-operate by not demanding sole bargaining rights with the Carnegie-Illinois Corporation. Therefore, it is possible for labor and industry to meet and settle their differences in a conciliatory manner. The example should not only be followed by other large industries, but should emphasize the need for sound leadership in labor unions. The line of action taken by this corporation should relieve pressure on the government to interfere in industrial disputes. Under the Walsh-Healey Contract Act, which requires companies receiving government contracts to limit their working hours to forty per week, the Carnegie-Illinois Corporation will be in a position to bid for government naval contracts, about which the company has recently been concerned. Proponents of this act have claimed that acceptance of its provisions by the steel corporations will increase purchasing power and decrease the number of relief workers. The steel agreement seems to bear out their argument, for the industry has now every prospect of continuing on full schedule. Large orders from the Navy, railroads, automobile factories, and numerous other industries await their attention. With their differences peacefully and reasonably settled, labor and industry can combine to accelerate recovery. Both sides are winners, not losers.

Within the past few months it has been deeply impressed on the public that the costs involved in a strike are tremendous and wasteful. There is a growing indication that public opinion will more and more function as a stabilizing force for industry and labor. It has not become articulate yet, but there is a good possibility that public opinion might have influenced the decisions of the company.

AN ERROR BY LABOR

IT has often been said that possession is nine-tenths of the law, but unfortunately our lawless and violent "sit-down strikers" have taken this statement too seriously. Should a domestic servant attempt a sit-down strike he would immediately be expelled, by force if necessary. But, with a large group, the situation becomes harder to control.

The sit-down strike is by no means an American invention. It has been imported from France, where revolutionists seized their employers' property and would have retained it if this had been possible. The American worker, however, is not considering revolution and war; he is merely seeking more money and power for his particular union. Unfortunately for him, the American worker's sit-down strike is scarcely beneficial to his union; it is, rather, detrimental. We cannot forget the fact that, no matter how weak the law has proven itself in this case, the sit-down strike is, nevertheless, lawless, and that its purpose, which is essentially intimidation, often degenerates into violence and destruction.

Public patience may soon reach its limit, and, when public opinion is aroused, little or nothing can stop it. As soon as general sentiment is aroused, the unions that tolerate or advocate sit-down strikes will go.

Labor has already suffered from illegal violence and force on its part, and should have learned its lesson. About sixty years ago, the Molly Maguires, a group which grew up in the Pennsylvania coal industry, wrought destruction, violence, and even murder. They flourished for a long time, but eventually public irritation caused the dissolution of the organization, which had set back for years the regulating of unions.

In the 1880's the Knights of Labor blundered into destructive methods. About twenty-five years ago Bill Haywood, leader of the Industrial Workers of the World, thought that violence and sabotage would prove useful tools in the organization of labor. This presumption was completely disproved; the I. W. W. was demolished by its own wanton methods. Haywood, disillusioned, died in Russia, while the unions prospered with wiser leadership.

Samuel Gompers, on the other hand, saw that unions had to develop along lines that do not include sabotage and lawlessness. Because he avoided violence, he was able to watch the disintegration of his rivals and the prospering of his progeny.

The forceful seizure of a factory accomplishes nothing and merely antagonizes those who can help labor. The government is often brought into contempt for its weakness and futility. This certainly benefits no one, especially not the worker who needs the aid of the government that he has helped to form. Unfortunately many of these strikers do not always wish to strike, but do so only because they are *told* to do so, under the threats of losing their already uncertain job if they should refuse.

GENERAL ELECTRIC CO.
SCHENECTADY, N. Y.

March 2, 1937.

To the Editor
The Tech Engineering News
Mass. Institute of Technology
Cambridge, Massachusetts

Dear Sir:

In your January number of this year, you have an article on the "Story of the Coolidge X-Ray Tube" by Millard B. Hodgson, Jr. I have just learned with keen regret of his untimely death.

Through an intimate acquaintance with his father, I came to know Millard Junior as a very small boy with a lovely disposition and the most winning smile I ever saw. Upon meeting him in his later life it was a pleasure to see that the charm of the small boy was still there.

I was very favorably impressed by his article on the x-ray tube, and rather surprised to see how many of the most important facts he had been able to unearth and bring together in a highly readable form.

In the light of his early promise, I feel that science has lost an able worker, and his associates a personal friend of great charm.

Very truly yours,
W. D. COOLIDGE.

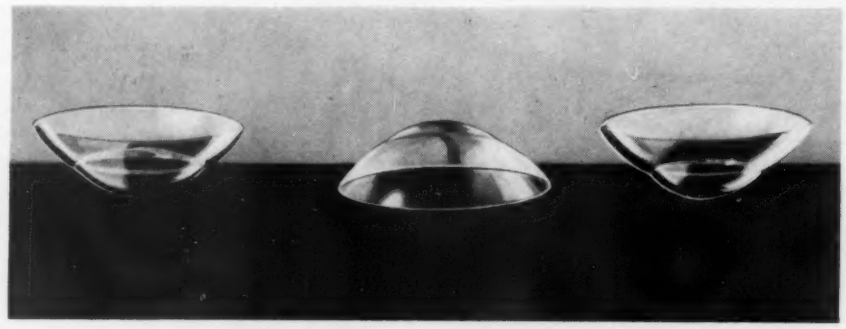
ENGINEERING DIGEST

SPRINGS

SINCE automobile springs must stand up under innumerable shocks — even closures until they bump — they must have an endurance limit in alternate bending above 85,000 pounds per square inch, and this means an ultimate tensile strength of about 200,000 pounds per square inch (and a definitely high yield point to prevent a gradual sag). These properties demand quenched high carbon steel, fine grained, alloyed with vanadium, molybdenum, or silicon and manganese. Heating prior to coiling may coarsen the grain, and coiling itself may set up uneven internal strains. Consequently, the best springs must be cooled slowly and evenly above the critical range to refine the grain. Quenching is done in a fixture which not only holds the spring to shape, but sprays it with oil jets under pressure, even as the fixture and its contents are totally immersed.

It is surprising how much rod is required for a single coil spring — about ten feet of it, beautiful steel, straight as an arrow, surface ground exactly round to remove mill scale, soft skin, and other superficial defects.

— *Metal Progress*



INVISIBLE LENSES

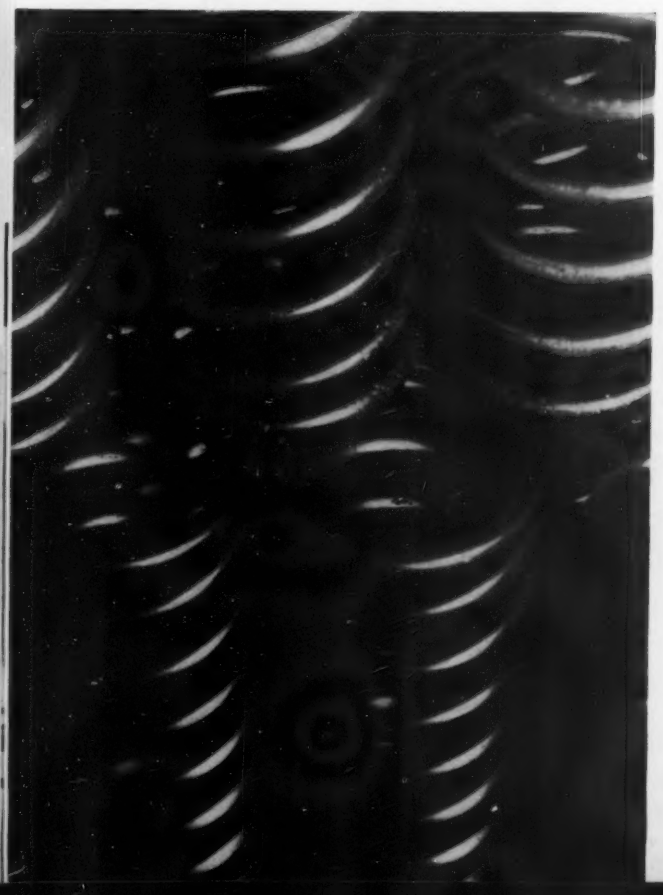
THREE thousand people in this country alone are now wearing contact lens, which, through improvements during the last few years, have become practical. Delicate refinements in the grinding of the lenses has resulted in the improvement to such a degree that an accuracy of .05 millimeter is now possible. Improvements in grinding processes now permit the lenses to be worn for long periods of time with comfort and safety since the inner surfaces of the little shells present a curved surface to the eyeballs.

The principle of invisible lenses was developed over one hundred years ago by J.F. Herschel. About a dozen years ago Carl Zeiss of Jena, Germany, began experimenting on the practicability of using contact lenses to overcome ordinary eye defects. Realizing that astigmatism is caused by slight irregularities in the shape of the cornea, researchers began to apply contact lenses to correct this condition. The lens is filled with a saline solution, thus forming a homogeneous contact between the glass and the eye. The center section of the lens and the solution refract light rays like a normal cornea.

Contact lens take more time to fit than ordinary lenses, often necessitating as many as six visits. A trial set of lenses is made to determine the proper curvature, after which the permanent lenses are ground from the prescription.

Being protected by the eyelid, contact lenses are virtually unbreakable, while they can be worn on a multitude of occasions. They are placed on the eye by a simple rubber suction tube (see illustration above and to the left), and when in place are unnoticeable. Drivers find contact lenses valuable as they do not steam up, or cause bothersome reflection.

— *Scientific American.*

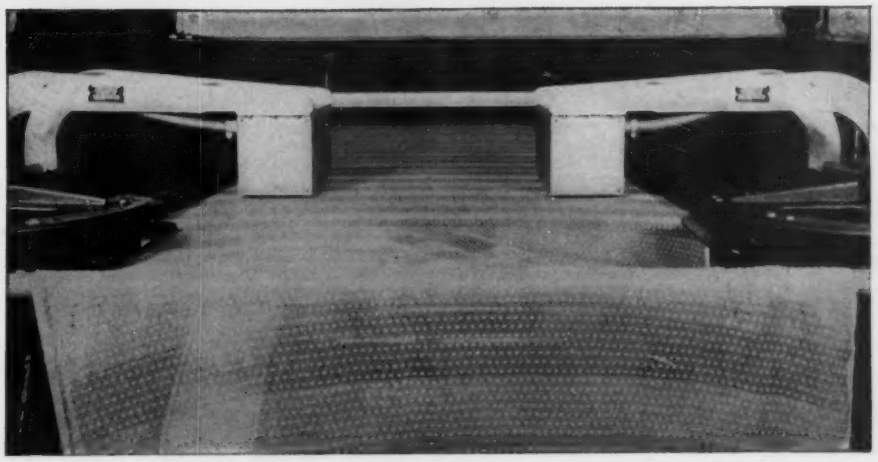


CORRECTING CLOTH SKEW

DISTORTION of the normally right-angle relationship of warp and weft that occur during finishing processes of cotton cloth causes a lot of worry to textile manufacturers. Customers demand that the weave be straight.

The best old method of handling this straightening process is one in which an operator watches the cloth and manually controls a motor that corrects misalignment of the weave. At best, he cannot accurately detect small skews at cloth speeds in excess of 40 yards a minute. Modern practice calls for cloth speeds up to 100 or 150 yards a minute.

General Electric came to the rescue of textile manufacturers with an ingenious photo-electric control device, a product of the general engineering laboratory. This device substitutes electric for manual control in the operation of the straightening motor in the old method. Its operation depends upon the frequency of interruptions caused by the threads as the cloth passes between two scanning lights and phototubes. The system is synchronized by Selsyn control.



Cloth speeds may vary from 20 to 140 yards a minute, and the weft count may vary from 20 threads an inch in open weaves to 100 threads an inch in close weaves. This means that the device operates with a frequency range of from 280 to 8400 cycles a second.

— *General Electric.*

HIGH ALTITUDE FLYING

OF the numerous physiological requirements that have to be considered in high altitude flying, the oxygen problem is of primary importance. There is still much research of an engineering nature left to be done as to the type of pressure cockpit best suited for high altitude flying because, contrary to popular belief, it is not the percentage of oxygen present that is so vital to life, but rather the partial pressure of the oxygen in the lungs.

Noxious gases such as carbon monoxide are still puzzling developers, and an instrument for recording the carbon dioxide composition of air is urgently needed.

For the sake of health and comfort, other important requirements are, temperature regulation, humidity control, ventilation, noise levels, and barometric pressure; all of which must be taken into consideration before the high altitude flying can be perfected.

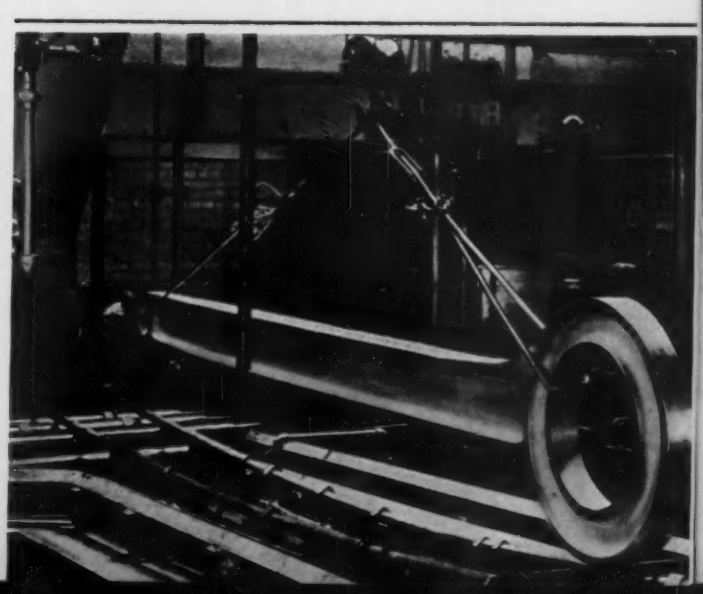
— *Aero Digest.*

NICKEL STEELS AND ALLOYS

ALLOY steels are playing a great part in the new era of locomotive construction. At the right is an illustration of a heat-treated alloy steel locomotive main rod that has just been chromium plated. It is one of the set of two twelve foot main rods and four nine foot side-rods which required the construction of a specially designed plating tank seventeen feet long. The chromium plating job on these rods is said to be the largest ever accomplished in one operation. In July, 1934, the Pennsylvania Railroad equipped a locomotive with a complete installation of roller-bearing main- and side-rod forgings, made from high-tensile strength alloy steel. A total reduction of 508 pounds was effected in the weight of the reciprocating parts by using high-strength nickel alloy steel. This weight advantage is more readily appreciated when one knows that there is a reduction in total crankpin load of approximately 48,500 pounds when the locomotive is travelling at a speed of 100 miles per hour.

One metallurgist summarizes the qualities of this nickel-molybdenum alloy steel as follows: (1) high tensile strength; (2) excellent impact values; (3) high fatigue resistance; (4) good surface hardness; (5) wide heat-treating range; (6) minimum distortion in heat treatment.

— *Machinery.*



RESEARCH IN REVIEW

COURSE XVI — Aeronautical Engineering

VISITORS in the large wind tunnel room of the Aeronautical Engineering Department will find that the size of our wind tunnel family has increased. Two new tunnels are nearing completion. These are not intended for airplane model testing, but for special research work.

The boundary layer research tunnel is a wind tunnel designed and operated for the experimental study of the boundary layer. The "boundary layer" is defined as a region close to a solid wall, where the effect of viscosity causes a decrease in the velocity of the fluid.

Imagine a flat plate in a uniform stream of air, placed so that the air is flowing along the plate. Then the two or three layers of molecules nearest the plate adhere to the plate; hence the velocity of the air here is zero.

As the distance from the plate increases, the velocity increases until it reaches a constant value, called the "stream velocity." Then the region near the plate, where the velocity is less than the stream velocity, is the boundary layer.

The boundary layer tunnel consists primarily of three parts: entrance, rest chamber, and test section. The entrance is circular in section, and houses an eight-bladed fan which blows the air through the tunnel. Immediately in back of the fan is a set of straightening vanes which remove the swirling motion of the air imparted by the fan. The air stream then diverges into the rest chamber where it receives its final straightening and the turbulence is allowed to die out as much as possible.

The air then passes through a rapidly converging throat and into the rectangular test section. One side of the section is a flat steel plate, three feet high and ten feet long, which has been nickel plated and polished on the inside. As the air blows along this plate, a boundary layer develops. This boundary layer is "measured" by inserting through each of twenty holes along the plate a pitot tube to measure the air velocity as a function of distance normal to the plate.

The side opposite the plate is movable so that boundary layer measurements can be made in accelerated or decelerated air streams. The top of the test section has windows so that one can look into the tunnel at any time.

Of course boundary layers develop on the other three sides of the test section, as well as on the test side, but slots are provided to blow it out of the tunnel on these three sides.

From the test section the air passes out of the tunnel and into the room, eventually to drift back to the entrance.

The second addition to the family is the new low speed wind tunnel, in which air speeds from a few inches per second to 150 feet per second may be obtained. This apparatus was built for the purpose of providing a means of accurately calibrating low airspeed instruments, such as meteorological anemometers and circulation indicators as used by heating and ventilating engineers.

An ordinary wind tunnel consists of a Venturi shaped duct, the throat of which serves as the test chamber, since the velocity is highest at that point. The new low speed tunnel has, instead of a single throat, four throat sections in series, each smaller than the preceding, so that the air moves progressively faster in passing through the various sections. Instruments under test may be placed in any of these throat sections, depending on the velocity range desired.

In the last and smallest test section the velocity is great enough to be measured with an ordinary pitot-static tube, and knowing this velocity accurately, the velocities in all the preceding sections may be found.

These wind tunnels are being constructed by students under the National Youth Administration, and represent some of the many accomplishments which have been made possible by the Federal Government in its policy of paying students for part time work.

COURSE IV — Architecture

IT often happens that a project started as a mere recreation turns out to be one of real value and usefulness. Such, apparently, will be the case with the model of the Jungfrau, started some time ago in the home workshop of Professor C. H. R. Mabie of the Division of Drawing. He first planned to use a very modest scale, the complete model to measure only about a foot square. It has since grown to nearly eight times that size.

Professor Mabie has always had a deep interest in Switzerland, a feeling fostered no doubt by parents who, having travelled extensively, often recounted the beauties and traditions of its mountains and valleys. Several years ago he was enabled to spend some months in the Bernese Oberland, thus obtaining more than a passing acquaintance with her mountains.

Since the first requisite for all relief maps is accurate contours, Professor Mabie sent to the Swiss Topographical Bureau at Bern and obtained contour maps of the region that he wished to represent. These maps are beautifully delineated, showing not only the contours, printed, by the way, in three colors to show the character of the ground they pass over, but all the forests, with the cliffs drawn in light and shade. Besides the many photographs that he brought home with him, Professor Mabie obtained from the Ad Astra Co. at Zurich many airplane photographs which proved of inestimable value. These were, however, often subject to distortion, and estimations had to be checked up with other photos and map measurements. Many more hours were spent in consultation of works on the geology of the Alps, glacier action, climatic conditions and Alpine scenery.

Professor Mabie's method of building the model is as follows. The contour lines on the government maps are traced on pieces of celluloid and enlarged up to the desired size in a lantern. These are drawn out on heavy paper and carefully compared with the original. By placing carbon paper on the back of these sheets it was possible to trace the contours on pieces of board five-eights of an inch thick, which represent an actual height of sixty meters. These then are cut out by means of a machine jig saw and nailed down according to a ground register. The space between contours is filled in with an asbestos material mixed with glue, which, when dry and hard, affords an excellent base on which to model the surface.

When the complete surface has been modelled, a mould will be made into which plaster of paris will be poured. This in turn will be retouched, painted, and here and there will receive a coating of different grades of sand to give it as natural an appearance as possible.

In accordance with the Swiss maps the metric system has been used throughout. The horizontal scale is $\frac{1}{5000}$ meters, while the vertical scale has been increased one-half in order to avoid the flatness so often apparent in small models of equal

scales. The whole model will be divided into nine squares, with the geological strata properly indicated on their cut sides. They will be mounted on a flat form in such a way that they may be easily separated for study. The central portion will remain stationary, while the others may be moved apart for a short distance on individual tracks; thus affording an opportunity to study them from all sides.

The territory represented includes the Jungfrau, Monch and Eiger, the Grosshorn, and the upper end of the Lauterbrunnen Valley. The Eiger, Guggi, Rotthal glaciers, and the start of the Aletsch glacier are carried out in realistic form. Three huts of the S. A. C. will appear as well as the Jungfrau joch hotel and part of the railroad leading up to it.

Aside from the pleasure Professor Mabie takes in constructing it, he thoroughly believes that such a model would be of great value in the study of geomorphology, and civil engineering, as well as geography and the adjustment of life to Alpine regions.

Furthermore as a museum exhibit, it would bring to the public the true colors and lusters of the rocks, aud glaciers; thus enhancing an appreciation of the beauty of Alpine scenery especially to those who may never visit the Alps.

COURSE V — Chemistry

PROFESSOR A. A. BLANCHARD has for a number of years given special attention to the study of the carbonyls of the heavy metals. Carbon monoxide combines directly with such metals as nickel, cobalt, iron, chromium, molybdenum, producing colorless volatile compounds, the so-called carbonyls, which seem to be at variance with many of the commonly accepted rules of chemistry. It is through the study of such apparent exceptions, that it may be made possible to discover more generally valid rules. Professor Blanchard has contributed several methods of preparing the carbonyls as well as a good deal of information about their behavior. He is at present most particularly interested in the carbonyl hydrides. In the series $Ni(CO)_4$, $Co(CO)_4H$, $Fe(CO)_4H_2$, nickel carbonyl is a non-electrolyte, cobalt carbonyl hydride is a mono-basic acid and forms salts of the type $KCo(CO)_4$, iron carbonyl hydride is a dibasic acid and forms salts of the type $K_2Fe(CO)_4$. The determination of the ionization constants of these acids is the immediate objective of the present studies.

Professor Blanchard has been asked to deliver a talk on this subject to the American Chemical Society at Chapel Hill, N. C., in April.

COURSE XII — Geology

THROUGH the generosity of Mr. Godfrey L. Cabot, Life Member of the Institute Corporation, the Department of Geology is to have a thoroughly modern spectrographic laboratory for geological research. The equipment will include a grating type spectrograph.

This fills a long-felt need in the department. Modern theory and technique in geology frequently require a knowledge of the elements present in rocks, minerals, and ores in amounts too minute to be determined by ordinary chemical methods of analysis. By special chemical methods a very few elements, for example, gold, may be determined accurately when present in amounts of 0.0x% or less. Because of the economic value of gold, special assaying techniques have been developed for determining minute quantities, and hence the geologist has accumulated a considerable fund of information on the provinces, types of rocks, and minerals in which gold occurs in the earth's crust.

Relatively little is known, however, of the distribution in rocks and minerals of such elements as Ge, Ga, In, Tl, Sc, and many others. For these elements as well as the small percentages of the more common elements, spectrographic means are necessary for ready determination. The significance of minute amounts of elements overlooked by ordinary analytical methods is frequently a critical factor in the study of geological origin. It is planned to use the instrument in studies of mineral composition as bearing on the genesis of ore deposits and igneous rocks.

COURSE XVII — Mathematics

AT the present time there are a large number of different research projects under way in the department. Dr. Struik is studying the application of tensor analysis to electrical engineering problems in accordance with the Kron Theory, and is busy on a book with Dr. Boyajian of the General Electric Company on tensors in electrical engineering.

A group of the analysts of the department, including Professor Wiener and Drs. Martin, Cameron, and Levinson, are engaged in research leading to an attack on analytic number theory by methods of averaging. Dr. Martin and Professor Wiener have just completed a paper on a new type of Tauberian theorem with applications to the problem of partitions. Dr. Cameron is working on absolutely infinite trigonometric developments, such as those found in the theory of almost periodic functions. Dr. Levinson has recently written an article on Tauberian gap theorems, and is now engaged, together with Professor Wiener, in the study of Waring's problem of the representation of integers as sums of a given number of powers of a given kind.

Professor Crout is engaged in research problems in applied mathematics, and Dr. Wadsworth in statistics. Professor Hitchcock is carrying on his researches which tie up with recent work in modern algebra. Mr. Reissner is studying a group of problems in elasticity which lead to integral equations of a difficult type.

COURSE XVI — Meteorology

SINCE 1931, when Technology began daily airplane ascents from East Boston for weather soundings, the conditions of the air to a height of three miles or more have been recorded whenever that airplane could fly. The Institute was responsible for these weather flights, and maintained a series each year from October 1 to May 31, until 1935, when the U. S. Weather Bureau with the aid of the Army took over the work. These airplane ascents have yielded and continue to provide extremely valuable information for the weather forecaster. The airplane has the disadvantages, however, of being unable to fly in hazardous weather conditions when upper air information is most urgently needed, and of not going above 20,000 feet; therefore, much valuable information was not available.

The Institute, in conjunction with Harvard University, is now running a daily series of ascents of radio-meteorographs attached to small balloons, which provide records in any type of weather from regions at twice or more the height to which the airplane goes. The aim of this joint project is to obtain a complete record of temperature and humidity up to the stratosphere and, if possible, above.

The radio-meteorograph is the joint product of Dr. Karl O.

(*Continued on page 51*)

(*Continued on page 39*)

A second factor of importance is the presence of influences disturbing the smoothness of flow of the winds. Notable in this respect is a rough or mountainous land surface, or the occurrence of horizontal or vertical wind discontinuities such that there may be generated turbulence between the two currents. A final factor is the moisture content of the air, since the heat of condensation is of great assistance in maintaining vertical convection in moist air. The maximum mean values of the temperature lapse rate in the atmosphere over the central United States, both summer and winter, are found between 16,000 and 23,000 feet. Consequently, as far as this factor is concerned, the 20,000 foot level should on the average be one of maximum turbulence at the high levels. However, the other factors are much less favorable to the production of turbulence at this height. The amount of water vapor in the air is much lower at lower levels and the influence of the roughness of the ground makes itself felt mostly in the first few thousand feet above the surface. Especially in the summer, however, when the atmosphere near the ground is strongly heated during the daytime, conditions of extreme turbulent activity frequently extend from the ground well above the 20,000 foot level. This is shown by the frequent occurrence of heavy thunderstorm activity, when the convectively formed clouds tower far beyond the 20,000 foot level and when the maximum vertical velocities in the convective currents are found to be near this altitude. During the summer season it is an exceptionally light thunderstorm which does not extend to the 20,000 foot level; probably all frontal, or wind-shift, thunderstorms are quite violent at this height. During the winter season however, one would probably find himself above most of the intense turbulent activity having its origin in the ground layers of the atmosphere. But during this season the 20,000 foot level often may be one of maximum turbulent activity and condensation in advance of Tropical Maritime air warm fronts, or in other words in the heavy precipitation area of cyclonic disturbances, or low pressure areas, in which the precipitation is furnished by warm moist air from the Gulf of Mexico.

At the 30,000 foot level in winter one would doubtless find himself above all of the violently convective type of turbulence which has its origin at low altitudes, although certainly moderate turbulence does occur at this level even in the winter season. During the summer season at this altitude one would be above the great majority of convective disturbances originating at low levels. Nevertheless, the more severe frontal thunderstorms and the violent convective type of thunderstorm characteristic of the tropics doubtless reach this altitude with considerable intensity. At this level one would find himself above most of the convectively turbulent activity of all ordinary extra-tropical low pressure areas, but in the case of the tropical hurricane it would be quite otherwise. These very violent storms of low latitudes occurring principally in the summer and fall extend their influence beyond the 50,000 foot level and are probably accompanied by violent convective turbulence to well beyond the 30,000 foot level.

The rate at which ice is deposited upon aircraft is to a first approximation proportional to the amount of sub-cooled water suspended in the atmosphere and is probably favored by a large size of the individual droplets in suspension. Consequently, the heaviest icing occurs at sub-freezing temperatures where condensation is taking place most rapidly, for with a high rate of condensation there will be a larger amount of water in suspension which has not had time to be precipitated. It is evident therefore that icing will be heaviest at temperatures not far below freezing, for at lower temperatures there is much less water vapor in the air to be condensed. The temperature zone in which heaviest icing occurs therefore lies between 32° F. and 15° F., while below 0° F. it is improbable that any dangerous amount of icing can occur. In view of this fact it becomes, obvious, then from the observed values of the mean temperature at the 30,000 foot level over the central United States which were quoted above, that it is very unlikely that any appreciable icing can occur at this level either summer or winter. At this altitude in winter one can expect to find himself above all the fine higher cirrus clouds which are composed exclusively of ice crystals. Not only would there be no possibility of icing under these conditions, but it is unlikely that even the horizontal visibility would be reduced very low. In summer on the other hand, the occurrence of much denser clouds at this elevation could be expected, particularly in connection with tropical disturbances and also the more intense thunderstorms. But it is very unlikely that under any conditions temperatures above 0° F. or any appreciable amount of icing would be encountered.

At the 20,000 foot level conditions are somewhat different. During the winter season, although quite dense clouds may be observed frequently at this level, it is improbable that in the latitude zone of the United States any heavy icing conditions would be encountered here. Undoubtedly the conditions most favorable for icing occur in connection with the Tropical Maritime air warm fronts at the lower latitudes, mentioned in the discussion of turbulence above. In such cases temperatures between 0° F. and possibly even 15° F. might be encountered in the Tropical Maritime air at this altitude. In such exceptional cases moderate icing might be expected. In the summer season, on the other hand, a mean temperature of +9° F, found to characterize this level, lies only a few degrees Fahrenheit below the temperature zone for maximum icing. Doubtless in many summer thunderstorms and in more general disturbances as well, the zone of maximum ice formation will be found at just about this elevation. In view of the extremely rapid condensation which occurs in the strong convection currents in this particular type of summer thunderstorm, icing conditions of an intensity seldom met with in winter at any elevation probably are of frequent occurrence at elevations between 15,000 and 20,000 feet, while even in the more general summer disturbances one could expect to meet with heavy icing conditions in this altitude zone.

Much more might be written about the flying weather which is to be anticipated at high altitudes under different conditions, but enough has been said to make it evident that even at 30,000 feet not all unfavorable weather conditions are eliminated. We might sum up the indications of the evidence of the present observational data by saying that by flying at 30,000 feet during the winter season all unfavorable weather conditions except those of strong winds and extreme cold would be eliminated. Under summer conditions the winds and coldness are less extreme but one would occasionally come within the zone of the markedly disturbed conditions of particularly severe thunderstorms, while flight through tropical hurricanes at this height would doubtless be highly inadvisable. By flying at the 20,000 foot level in the winter season most of the icing hazard and most of the low level turbulence activity would be avoided, but it would by no means take one above the disturbance of the ordinary winter low pressure areas, so that considerable cloudiness and occasionally moderate icing might be expected at this altitude. In summer the most extreme icing conditions and turbulent activity to be found at any level at any time of year might be expected at or just below this altitude. Needless to say this applies also to cloud density.

WELDED SHIPS

(*Continued from page 38*)

Predictions of any sort are always dangerous, especially in this time of science and engineering. The world today is full of realities that only a few years ago were considered fantastic and idle dreams by the wise. It is, however, safe to say that economics determine the fate of such ideas. And so it is with welding as applied to ships — the future of the process will depend upon the outcome of the controversy of costs versus advantages gained. The problems confronting us now are probably not as great as those that had to be overcome at the beginning of the iron ship era. In the last analysis, the question of erection costs will have to be settled by the designer. We have already learned that the welded ship has to be designed primarily as such. Methods that were applicable to riveting can no longer be followed. Every step taken must be well thought out and executed along the lines which experience shows are the best.

In electric arc welding, the shipbuilder has acquired a very useful and efficient tool that has won a definite place in the art of shipbuilding, and we are daily acquiring greater skill in its use. There is, of course, a world of room for improvement, that is if welding is to replace rivets entirely. The shipyard technical staffs of the future will, naturally, as at present, be supplied in a great measure by our engineering schools and colleges. Thus, it is upon these men, who as students must familiarize themselves with the fundamentals of welding design, that the further application of this tool rests.

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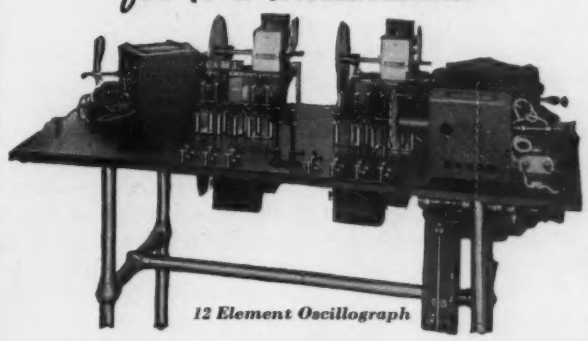

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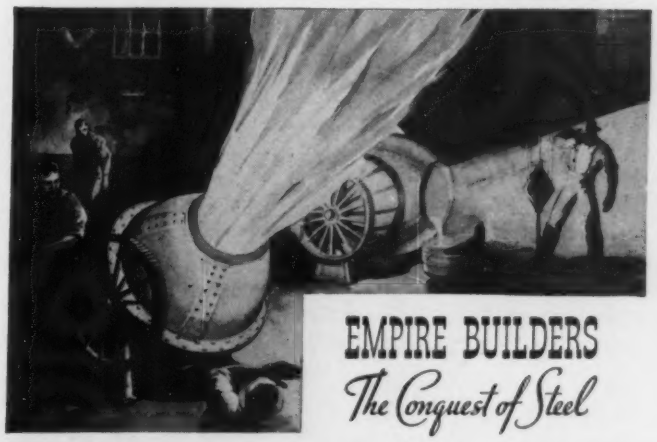

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COMMERCIALIZED AIR

(*Continued from page 35*)

given off by thirty-five passengers at rest will be removed to the extent necessary for comfort.

In the textile industry, as in other production businesses, natural weather conditions have become outmoded because of the ever increasing complexities arising in manufacture and in quality demands. During the manufacture of rayon, green viscose is stored in cellars where slow aging takes place. A constant temperature is necessary to insure a constant and suitable rate of chemical reactions. Following this storage the liquid viscose is spun into thread. A relative humidity of about eighty percent is necessary to retard evaporation and prevent crystallization of the sulphates on the finished threads. The fumes from the sulphuric acid bath it receives must be removed. A temperature of seventy degrees Fahrenheit, dry bulb, and a relative humidity of eighty-five percent is found to be desirable for spinning, while twisting requires seventy degrees Fahrenheit and a relative humidity of sixty-five percent.

Rayon, like other textiles, absorbs moisture from the surrounding air and consequently, a change of humidity causes a corresponding alteration of the moisture content in the rayon. Yarn tends to lengthen as the humidity increases and shrinks when the humidity decreases. The yarn reaches its elastic limit very soon in a high relative humidity. As the moisture content decreases the yarn becomes stronger and elongates to a smaller extent. If weaving is done when there is a low humidity, the yarn will tangle and stretch as soon as exposed to moist air. If the weaving is done in high moisture content air, the yarn will be stretched. When brought into a dry atmosphere, it will contract. If the tension is not relieved, there will be breakage and delay. It is therefore paramount to have a "man-made atmosphere" throughout the reeling, sorting, inspection, spooling, quilling, and warping processes.

The preparation process in cotton mills is best carried out with a humidity of fifty to fifty-five percent. Greater flexibility is needed for spinning so the humidity is correspondingly increased. Finer woven and higher grade textile require higher humidity, while heavier and coarser goods can be made under drier air conditions.

Formerly, high grade woven materials could be manufactured only where there was the geographic advantage of a moist climate, such as in England, but now the desirable weather conditions can be manufactured at will. These peculiarities of textiles require exacting atmospheric conditions that only the flexible adaptability of air conditioning has been able to meet successfully.

Let us turn now to some of the industries that are engaged in producing luxuries of inelastic demand. You are all familiar with the effect of heat on candy. Excess heat and the candy manufacture just do not get along together. The dangers of excess heat have been eliminated by the application of man-controlled weather to the needs of the candy industry. An explanation of the air conditioning system installed in a chocolate and cocoa factory in Philadelphia shows the requisites of quality manufacture. On the first floor chocolate products are wrapped and packed at a temperature of sixty-five degrees Fahrenheit and a relative humidity of fifty percent. On the same floor offices are kept at a temperature of seventy-six degrees and a relative humidity of forty percent. The chocolate dipping is best accomplished at a temperature of sixty-five degrees and a humidity of forty to fifty percent. Under these conditions the chocolate coatings set in about fifteen seconds and result in a smooth lustrous candy with no finger marks. The third floor storage of such perishables as dried buttermilk in bags, raisins, and nuts require a dehumidifier of higher capacity than is used in the rest of the building. For this reason a temperature ranging from fifty-two to sixty degrees Fahrenheit is maintained. To reduce the heat loss and to save refrigeration, the air conditioned part of each floor is enclosed by insulated partitions composed of four-inch tile, two-inch cork, and one-half inch plaster on both sides. Many other factories such as this one make "every day a good day" and meet the demand for quality with "air conditioned candy."

Keen competition in the tobacco industry has necessitated a combination of mass production (over 83,000,000,000 cigarettes a year) and quality. This combination is made possible only by mechanical control of the atmosphere, since practically every step in the making of cigars and cigarettes depends on the moisture content and temperature of the surrounding air. The tobacco that is to be used in cigars and cigarettes must be uniformly soft and pliable. If the tobacco is too dry it becomes brittle and breaks when handled. The color and the mellow flavor, which are so highly advertised, are retained only by controlled relative humidity. Before the tobacco leaves are stored away for aging, they must be dried to a moisture content of ten percent by means of air conditioning. It ordinarily takes tobacco a period of from two to four years to ferment or age, because the period when the climatic condition favors "sweats" comes only twice a year. With properly applied air conditioning, this whole process of fermenting can be accomplished in a few weeks. The tobacco is then taken out of the fermenting room and exposed to a high humidity, obtained by means of mechanical weather units, and is made soft and pliable. The stripping operation, which follows, is now much simplified. In this procedure, the stem and coarse fibers can be removed with ease. The moisture content necessary for stripping is above that desired for blending and manufacturing, so the tobacco is subjected to a par-

(*Continued on page 50*)

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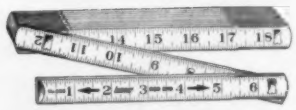

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FILMS

(*Continued from page 33*)

United States, in England, and in Germany. More sensitizing materials have been found, some of which have a practical application. So great has been the success of these compounds, that the older non-color-sensitive films and plates are being rapidly displaced by the general use of supersensitive panchromatic materials for all purposes, even in amateur photography where the greatest resistance to change has been noted.

In the search for sensitizing materials for the infra-red end of the spectrum, the ultra-violet region has not been neglected. On account of the impenetrability of gelatin to extreme ultra-violet light, ordinary photographic plates are not sensitive to wave lengths much shorter than 2,200 Å. It was found that plates bathed in fluorescent materials, which transform short wave lengths into longer ones that can penetrate the gelatin, were useful down to 580 Å. One of the most successful of the ultra-violet sensitizing materials is the beautifully fluorescent organic compound (not a dye) bearing the chemical name, dihydrocollidine-dicarboxylic acid diethyl ester. This compound is conveniently applied by bathing plates in solutions of it. The use of this material gives very good photographic images not only in the region transmitted by quartz but in the Schumann region and even in the case of the shorter wave lengths available in the vacuum spectrograph.

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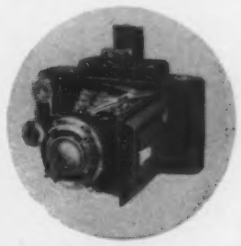

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COMMERCIALIZED AIR

(*Continued from page 48*)

tial redrying, which necessitates controlled humidity. Storage in the "bulk room" requires controlled temperature, air movement, and air cleanliness.

In the Philadelphia plant of the American Tobacco Company, production would fall from 4000 to 3600 cigars daily per machine because of the effect that normal summer temperature and humidity have on the tobacco. This ten percent decrease in production was entirely eliminated when an air conditioning system was installed. The Bayuk Cigar Company in Philadelphia has made extensive use of controlled atmosphere. In this factory there are four compartment type drying systems for filler tobacco, five fermentation rooms, a finished cigar conditioner, special ventilation for offices, and two low temperature storage rooms for processed tobacco. The two latter rooms are equipped for maintaining eighty-five to ninety percent humidity and a temperature of sixty-five to seventy-six degrees Fahrenheit. Remarkable economies have been propagated by the use of modern air conditioning units in the tobacco industry. The waste ordinarily caused by varying weather conditions has been reduced to a minimum and the quality resulting has naturally increased business.

Modern cooling has invaded the brewery and made for production economies as well as quality improvements. In the making of beer and ale, controlled temperature and humidity are necessary over a long period of time. This can be readily seen when we trace the steps in its manufacture. At the starting room, the wort, cooled to a temperature of forty-five degrees Fahrenheit for lager and fifty-five degrees for ale, is collected in open tanks, pitched with yeast, and fermentation is started. The fermentation process continues for several days. During this time much heat is generated, of which only a part is absorbed by the wort. The rest of the heat passes off into the room where it is imbibed by air cooling units. In addition to the heat passing off, there is a large quantity of carbon dioxide evolved. To prevent dangerous concentration of this gas in the room, a ventilating system is used to bring in fresh air and to carry out the foul air. Because of the use of a large amount of water for washing tanks and the presence of saturated carbon dioxide vapors, mold growth would be propagated and the room would have an unbearably high humidity if it were not for the air conditioning machinery. During the winter, when the temperature is too low to allow for dehumidification, it is necessary to introduce heat into the room.

After the fermented wort is drawn off, there remains a large amount of yeast which is taken to the yeast storage room where the copious use of water necessitates controlled humidity. The air in this room must be at a temperature of thirty-two to thirty-four degrees Fahrenheit and absolutely pure to guard against infection and spoilage of the yeast. Mold growth is checked by dehumidification. Finally, in the stock rooms the beer and ale must be kept at uniformly low temperature (thirty to thirty-two degrees Fahrenheit) and low humidity. Hops, which give ale or beer its bitter tang and aroma, must be kept in a crunchy condition and without loss of the essential hop ingredients. In order for them to retain these desired conditions, it is necessary that they be kept in mechanically treated air at a temperature of thirty-two to thirty-six degrees Fahrenheit and at a humidity of sixty-five percent. Atmospheric changes, which formerly delayed production in the brewery and caused untold damage, do not worry the modern brewer who has modern cooling.

The high efficiency of workers in comfortable and healthful surroundings brings inestimable gain to industries. As a result of an installation in the machine shop of the International Business Machines Corporation, the number of treatments for colds was decreased by fifty percent. The estimated total of dirt taken from the recirculating units equals 935 pounds yearly in addition to the 100 pounds of dirt removed each year from the fresh air units. From the sand molding room of the Ford Plant, air washers remove forty-two tons of dirt weekly. This dirty, humid job in the molding room has been made human by the advent of controlled humidity and mechanically cleansed air. At the Philadelphia plant of the American Tobacco Company, an average of fifty girls daily for seventy-five days during the summer would become sick or indifferent to their work and would work only one-half day, leaving at noon. After air conditioning was installed the average lost time for the seventy-five day period dropped to five girls out one-half day. The gross savings resulting from reduced labor inefficiency and increased production amounted to nearly thirty thousand dollars per year. Since the total owning and operating cost of the air conditioning units amounted to only slightly over six thousand dollars that year, the American Tobacco Company actually profited by more than twenty-three thousand dollars.

Space does not permit elaboration on every industry that has adapted air conditioning and profited by it. According to the Bureau of Census, Department of Commerce, between January and July, 1936, a total of nearly twenty-five million dollars in orders for air conditioning equipment was booked by ninety-eight manufacturers and according to recent statistics the number of summer installations in 1936 have surpassed those of the previous year by 44.2 percent. Commercialized air has indeed created its own vast market and firmly subordinated industry to it.

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RESEARCH IN REVIEW

(*Continued from page 45*)

Lange, formerly in charge of the Institute's airplane work, but now research assistant at the Blue Hill Observatory of Harvard University, and Arthur E. Bent, research assistant of the Blue Hill Observatory. The meteorological portion, designed by Dr. Lange, consists of a very small barometer, thermometer, and hygrometer, from each of which a silver pointer extends to a small cylinder. The cylinder, rotated once every half minute by specially constructed clockwork, has a platinum wire wound about it in the form of a helix. Each time the wire passes under one of the silver pointers an electric current passes through the radio transmitter, which emits a signal. In addition to the three weather pointers, there is an arm to report the actual speed of rotation of the cylinder. As each pointer changes its position in response to changes in pressure, temperature, or humidity in the air, the interval of time between one contact with the platinum wire and the next will vary. It is this variation in time with respect to the speed of rotation that indicates the changes in the weather elements. Shields keep sunlight and rain off the instrument.

The radio transmitter, designed by Mr. Bent, is enclosed in a box of half-inch balsa wood, which serves as an effective insulator against sudden temperature changes. It consists of two tubes with small coils adjusted to a frequency of 68 megacycles powered by tiny, specially-made batteries.

Transmitter and meteorograph are suspended from the balloon by the eight-foot radio antenna and a three-foot rubber cord. The balloon, made of latex, is about four feet in diameter, and will expand to a diameter of fourteen feet before breaking. When inflated, it can lift two pounds to a height of 100,000 feet. This height has twice been exceeded in ascents from Blue Hill Observatory.

Harvard University is supplying the radio-meteorographs, balloons, and hydrogen, while Technology will do most of the calibrating, launching, recording, and reporting. The results will be available to the U. S. Weather Bureau, and to both Technology and Harvard for classes and research purposes.

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ASTRONOMY

(*Continued from page 31*)

countless numbers in the field of his telescope as he swept it along the Milky Way, reminding one of those lines of the immortal Milton:

"A broad and ample road
Whose dust is gold and pavement stars,
As stars to thee appear seen in the Galaxy,
That Milky Way, that nightly
As a circling zone thou see'st powdered with stars."

While surveying the Milky Way, he was astounded with dark areas where scarcely any stars appeared at all. It seemed to him that they were windows through which he looked into the blackness of the void beyond the stars. On finding one of these black holes in the constellation of Scorpio, Herschel is said to have exclaimed, "Hier ist verhaftig ein Loch im Himmel!" The study of these dark areas by our modern instruments has convinced us that in place of empty space through which we look into the void beyond, these dark areas in the Milky Way represent vast patches of obscuring matter between us and stars in the galactic background. It is truly surprising, however, that Herschel's conception in making a picture of the universe should be so nearly in accord with that revealed today by telescopic observations.

In his extensive survey of the heavens, Herschel discovered thousands of patches of a nebulous character, faintly luminous even in his larger instruments, — the so-called nebulae. Only two of these are bright enough to be glimpsed by the naked eye at all, — the great nebula in the sword of Orion now scintillating in the southwest during these spring evenings, and another known as the great nebula in Andromeda not far from the familiar constellation of Casseopeia's Chair. It so happens that these two nebulae represent what we know today to be of contrasting types. The great nebula of Orion is a mass of glowing gas made luminous most probably by the excitation of the radiation from neighboring stars. Its distance is not great as distances to nebulae are reckoned, for it is well within our own galactic system, and rather a close galactic neighbor at that. The great nebula in Andromeda which appears as an elliptical patch in a telescope of moderate power is an aggregation of stars, or suns like ours, so far away that it takes light a million years to reach us after it has left that distant system. Such an enormous distance places it far beyond the most generous limits that modern astronomy will allow for our own galaxy. If we regard our galaxy of stars as our universe, then the Andromeda nebula in this sense is indeed another universe by itself. It is one of perhaps a million such objects, most of which are many times further away and appear to be wisps of light in our greatest telescope. These are the extra-galactic nebulae.

It was quite impossible, however, for Herschel to distinguish analytically between the characters of these contrasting types of nebulae. Any fuzzy object which, in his telescope, would not be resolved into independent stars was quite likely assigned to the general class of nebulae. With his bigger and better instruments he began to discover that many of these nebulous patches of light could be resolved into independent clusters of stars, many of which were globular in shape. Could it be, thought Herschel, that, if it were possible to build telescopes big enough and powerful enough, all of these faint nebulae might be resolved into aggregations of stars? Herschel could ask the question; he could not answer it. His predecessors have, however, answered his query. It has been only since the invention of the spectroscope and its application to astronomy in the analysis of starlight that the difference between the Orion nebula and the Andromeda nebula could be delineated.

EDITOR'S NOTE: Dr. Stetson has written a supplementary article discussing the modern phases of astronomy. This article will be published in next month's issue.

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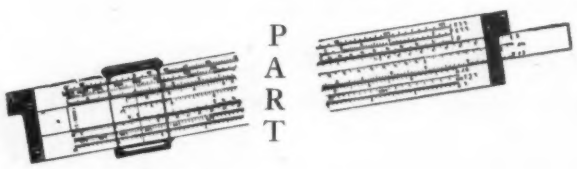

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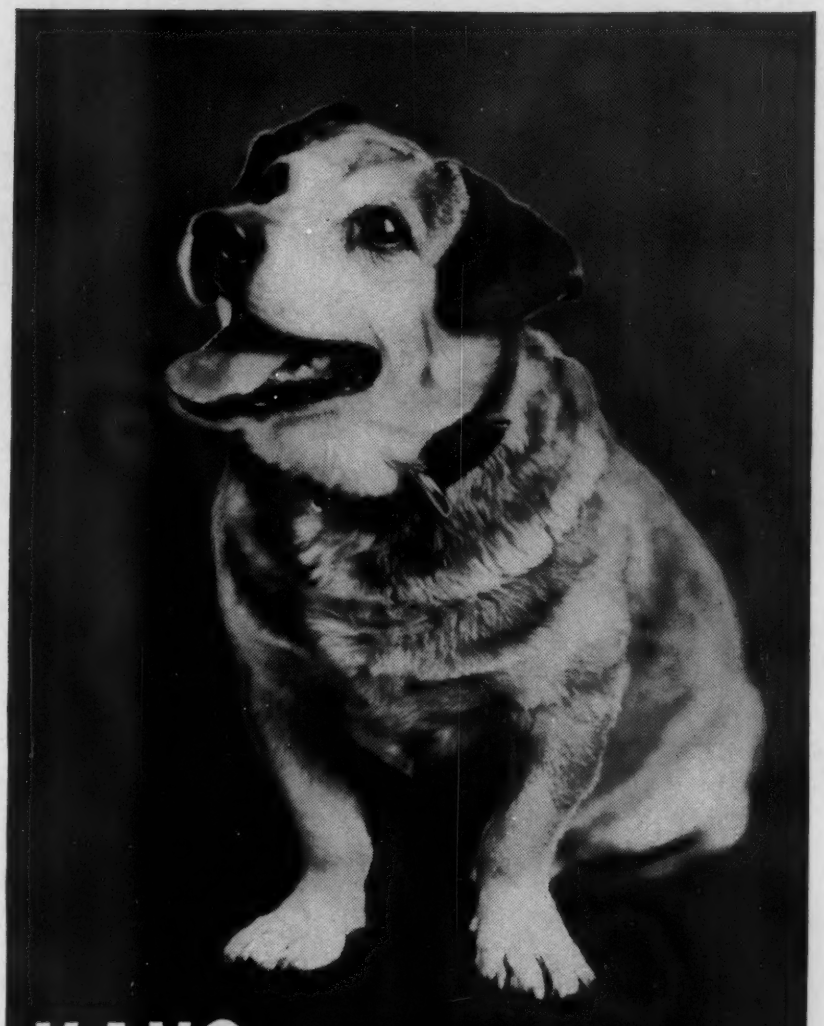


KAYO saved the day

A CHURNING flood had taken out the telephone line across a Colorado stream. Repairmen couldn't wade it because of quicksand—couldn't cross elsewhere and bring back the line because of obstructions.

Then Kayo's master had an idea. He went upstream, crossed, came back and whistled. Kayo jumped in—swam across with a cord tied to his collar. With this cord, the wire was soon pulled over—communication was restored.

A small incident. But it typifies the ingenuity which helps Bell System men and women to give you the world's most dependable telephone service.

BELL TELEPHONE SYSTEM

Why not telephone home more often? Rates to most points are lowest after 7 P. M. and all day Sunday.

G-E *Campus News*

ICE WATER

New electric drinking-water coolers introduced by General Electric have replaced the antiquated ice-cooled type on several prominent Midwestern railroads. This is another step in the modernization program being carried on by railroads to increase passenger traffic.

The new coolers are designed to overcome many disadvantages of the ice-cooled units. With foot operation of the self-contained units, only one hand need be used to get a drink. Cleanliness is promoted because of the absence of ice-filling operations, and the expense for maintenance and service is reduced to a minimum.

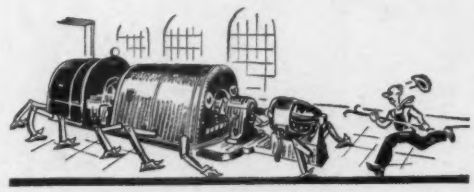
The water is automatically maintained at a healthful and refreshing temperature through thermostatic control. Coolers are designed either as self-contained units or as separate cooling and refrigerant condensing units for remote installations in the car.

AS VACUUM TUBES GREW UP

As the vacuum tubes grew, they found their style cramped because metal could be sealed to glass only in thin strips. Research took up the problem, and it is now possible to fabricate glass and metal together, in any size or shape, very much as two metals are fabricated.

In a successful glass-to-metal seal, the temperature coefficients of expansion of the glass and the metal must agree exactly over a wide range of temperature. Painstaking investigation—much of it in the General Electric Research Laboratory, at Schenectady—developed new alloys and new glasses, which could be used for this application.

The first application of this new knowledge has been in metal radio tubes, now standard in almost all radio receivers. Power thyratrons, switches, capacitor bushings—all these follow along the new trail. We cannot predict how far this new technique will go, but the possibilities are numerous and inviting.



TURBINE STEEL CREEPS

If the wrong kind of steels were used in turbine construction, the machine would not go creeping across the floor with the operator in hot pursuit, but the results might be even more disastrous.

Part of the increase in efficiency that has come about in the power-generating field in the last few years has been due to increased steam temperatures and pressures. As a result, the modern turbine shell runs, almost literally, red hot. This shell must withstand pressures such as exist half a mile down in the ocean and must keep a 20-ton rotor spinning perfectly in line. Heat softens metal, just as it softens candy, and permits it to stretch. This stretch, however, must be kept to the merest creep—about one part in 1000, if the changes are uniform.

In the Schenectady Works turbine shop, automatic electric furnaces hold samples of turbine steel at the temperature which will occur in the turbine. Gauges, which indicate changes of one part in a million, measure the creep as the pieces are exposed to heat for years at a time. From these tests, the best steel is selected.

It has been largely due to this research carried on by General Electric that the temperature and pressure of steam used in power generation have been raised to unexpected highs in the last few years.

96-363DH

GENERAL ELECTRIC

The Kendall Printing Company